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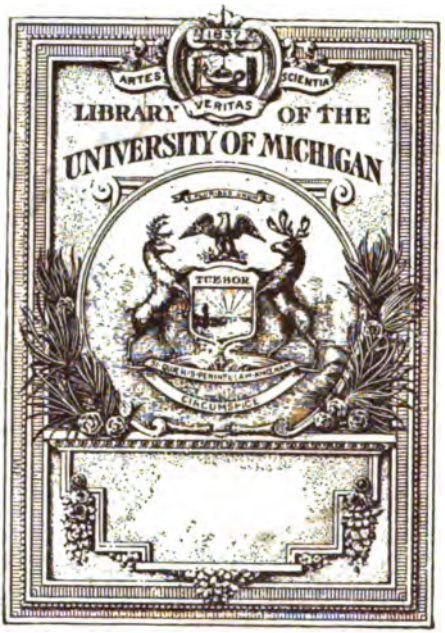

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TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1904

VOL. XXXVII.

(TWENTIETH OF NEW SERIES)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

BY

A. HAMILTON

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NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867"; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER "THE NEW ZEALAND INSTITUTE ACT, 1903."

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EX OFFICIO.

His Excellency the Governor.
The Hon. the Colonial Secretary.

NOMINATED BY THE GOVERNMENT UNDER CLAUSE 4.

*Sir James Hector, K.C.M.G., M.D., F.R.S.; E. Tregear, F.R.G.S.; John Young; J. W. Joynt, M.A.

ELECTED BY AFFILIATED SOCIETIES UNDER CLAUSE 4.

Wellington: Martin Chapman; Professor T. H. Easterfield, M.A., Ph.D. Auckland: Professor A. P. W. Thomas, M.A., F.L.S.; J. Stewart, C.E. Napier: H. Hill, F.G.S. Christchurch: Professor Charles Chilton, D.Sc., F.L.S.; Captain F. W. Hutton, F.R.S. Westland: T. H. Gill, M.A. Nelson: L. Cockayne, LL.D. Otago: A. Hamilton; G. M. Thompson, F.L.S.

OFFICERS FOR THE YEAR 1903–4.

PRESIDENT: Captain F. W. Hutton, F.R.S.

HON. TREASURER: J. W. Joynt, M.A.

EDITOR OF TRANSACTIONS: A. Hamilton.

SECRETARY: T. H. Gill, M.A.

AFFILIATED SOCIETIES.	DATE OF AFFILIATION.
Wellington Philosophical Society ...	10th June, 1868.
Auckland Institute	10th June, 1868.
Philosophical Institute of Canterbury	22nd October, 1868.
Otago Institute	18th October, 1869.
Westland Institute	21st December, 1874.
Hawke's Bay Philosophical Institute	31st March, 1875.
Southland Institute	21st July, 1880.
Nelson Institute...	20th December, 1883.
Manawatu Philosophical Society ...	16th January, 1904.

* Renominated January, 1904.

NEW ZEALAND INSTITUTE ACT.

THE following Act reconstituting the Institute was passed by Parliament:—

1903, No. 48.

AN ACT to reconstitute the New Zealand Institute.

[*18th November, 1903.*

WHEREAS it is desirable to reconstitute the New Zealand Institute with a view to connecting it more closely with the affiliated institutions:

Be it therefore enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. The Short Title of this Act is "The New Zealand Institute Act, 1903."

2. "The New Zealand Institute Act, 1867," is hereby repealed.

3. (1.) The body hitherto known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as may hereafter be incorporated in accordance with regulations to be made by the Board of Governors as hereinafter mentioned.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

4. The control and management of the Institute shall be in the hands of a Board of Governors, constituted as follows:—

The Governor;

The Colonial Secretary;

Four members to be appointed by the Governor in Council during the month of December, one thousand nine hundred and three, and two members to be similarly appointed during the month of December in every succeeding year;

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year;

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year.

5. (1.) Of the members appointed by the Governor in Council two shall retire annually on the appointment of their successors: the first two members to retire shall be decided by lot, and thereafter the two members longest in office without reappointment shall retire.

(2.) Subject to the provisions of the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

6. The Board of Governors as above constituted shall be a body corporate, by the name of the "New Zealand Institute," and by that name they shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

7. (1.) The Board of Governors shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) It shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) It shall have power to make regulations under which societies may become incorporated to the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with, and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property hereinafter vested in it, and of any additions hereafter made thereto, and shall make regulations for the management of the same, for the encouragement of research by the members of the Institute, and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

8. Any casual vacancy on the Board of Governors, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board of Governors.

9. (1.) The first annual meeting of the Board of Governors hereinbefore constituted shall be held at Wellington on some

day in the month of January, one thousand nine hundred and four, to be fixed by the Governor, and annual meetings of the Board shall be regularly held thereafter during the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board of Governors may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

10. The Board of Governors may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in the colony by any means that may appear desirable.

11. The Colonial Treasurer shall, without further appropriation than this Act, pay to the Board of Governors the annual sum of five hundred pounds, to be applied in or towards payment of the general current expenses of the Institute.

12. (1.) On the appointment of the first Board of Governors under this Act the Board of Governors constituted under the Act hereby repealed shall cease to exist, and the property then vested in, or belonging to, or under the control of that Board shall be vested in His Majesty for the use and benefit of the public.

(2.) On the recommendation of the President of the Institute the Governor may at any time hereinafter, by Order in Council, declare that any part of such property specified in the Order shall be vested in the Board constituted under this Act.

13. All regulations, together with a copy of the Transactions of the Institute, shall be laid upon the table of both Houses of Parliament within twenty days after the meeting thereof.

REGULATIONS.

THE following are the new regulations of the New Zealand Institute under the Act of 1903 :—

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by "The New Zealand Institute Act, 1903."

INCORPORATION OF SOCIETIES.

1. No society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1903" unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or some other branch of knowledge to which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as afore said shall provide for the expenditure of not less than one third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

REGULATIONS REGARDING PUBLICATIONS.

(*a.*) The publications of the Institute shall consist of

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Board of Governors shall determine what papers are to be published.

(*c.*) Papers not recommended for publication may be returned to their authors if so desired.

(*d.*) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e.*) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f.*) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

General Regulations.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. Subject to "The New Zealand Institute Act, 1903," and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

9. In voting on any subject the President is to have a deliberate as well as a casting vote.

Management of the Property of the Institute.

10. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt, and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

11. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

12. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary

of the Institute, may nominate for election as honorary member one person.

13. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

TRANSACTIONS

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1904.

I.—MISCELLANEOUS.

ART. I.—*Maori Medical Lore: Notes on the Causes of Disease and Treatment of the Sick among the Maori People of New Zealand, as believed and practised in Former Times, together with some Account of Various Ancient Rites connected with the Same.*

By W. H. GOLDIE, M.D.

[*Read before the Auckland Institute, 7th September, 1903.*]

With a preliminary note by Elsdon Best.

(HAVING collected a considerable amount of notes on the subject of disease among the Maori people and its treatment, I bethought me of placing such notes in the hands of some qualified person for compilation, with a view to publishing the same. Hence it was that I handed over all such notes to Dr. W. H. Goldie, of Auckland, who proceeded to add to them his own collection, culled from many works on New Zealand, Australia, Polynesia, &c Unfortunately, before the compiler had completed his task he was compelled by ill-health to give up all work, professional and otherwise. He therefore forwarded to me the MS. of his paper, in so far as he had completed it, with a request that I would prepare the same for laying before the Institute, adding that only about two-thirds of the paper had been written when he was compelled to cease work. He writes me, "The bulk of the paper is really yours, but rearranged by me. The section on drugs is, unfortunately, quite unfinished. I have copious notes on pharmacy, poisons, &c., which I am unable to compile." Regarding the information contained in the following paper, the original matter is my own, having been collected by me from members of the Tuhoe Tribe of Maoris of New

Zealand, while the balance of the paper is composed of extracts, &c., from many works, and is the result of some years of careful research on the part of Dr. Goldie. I fail to see that a non-professional person, who is a mere collector of notes, is competent to edit or rearrange the matter contained in this paper. It will therefore be presented in practically the same form as it was in when it reached my hands. My own contributions to this paper have been taken from two articles written by myself, but not yet printed, on "Maori Treatment of Disease," and "Rites and Customs pertaining to Birth, &c., among the Maori People." As so many works have been drawn upon in the compilation of this paper, it is perhaps needless to say that I do not agree with some of the statements therein. Regarding the numberless decoctions, &c., used as medicines in modern times by the Maoris, it is certain that nearly all such have come into use since the arrival of Europeans, and that very few internal medicines were used by the old-time Maori.—ELSDON BEST.)

The following notes have been collected and compiled with a view to placing on record some account of the diseases which afflicted the Maori in past times, as also those introduced by Europeans; and to explain the manner in which a primitive, neolithic people looked upon disease, as to origin and treatment thereof. Knowing, as we do, the Maori to be an extremely superstitious people, it is not surprising to note that they had made but little progress in the inquiry as to the cause and cure of disease; indeed, their treatment of disease lay in the sphere of magic and shamanism. Hence we shall note in this article many curious beliefs, myths, and superstitions connected with sickness. The Maori appears, perhaps, to less advantage in this than in any other department of knowledge, for he was completely in the hands of an unscrupulous and ignorant priesthood. It will be observed that universal use was made of charms and incantations to prevent and cure disease, &c. Many hundreds of such charms were carefully conserved by the shamanistic priests, and handed down to their successors. There were also many singular rites performed in connection with sick persons, but of these we have by no means a full or clear account. This paper, although lamentably incomplete, will yet record a considerable amount of matter which now for the first time sees the light.

CLASSIFICATION AND DIAGNOSIS OF DISEASES.

The Maori, says Best, divided the causes of death into four distinct groups—namely (1) *Mate atua*, or death due to supernatural influences—*i.e.*, demons, gods, witchcraft; (2) *mate taua*, by war; (3) *mate tara whare*, natural decay; and

(4) accidental, and by suicide. Class 3 is sometimes termed *mate aitu, hemo o aitu,* or *mate koeo.* The last expression is applied to any sickness in which a person wastes away, but is sometimes used in a general sense, as given above. *Hau koeoeo* is a slight indisposition, as sometimes felt by a person on rising in the morning. Natural death originated with Hine-nui-te-po, death not entering into the original scheme of the universe, according to Maori mythology.

Mate atua includes death due to *atua,* sent either by the gods or deified ancestors, or by sorcerers. "The word *atua,*" according to Mr. Elsdon Best, "means 'demon,' and never had the meaning of beneficent spirit or Supreme God." Speaking of the terrible epidemic known as the *rewharewha,* an old native said, "It was that *atua* [*i.e.,* the *rewharewha*] that destroyed the Maori people and so reduced their numbers." Likewise, the terms *kaiuaua, puhi-kai-naonao, papaka,* and a number of others are applied both to the *atua* producing the disease and to the disease itself. It would appear that these *atua* are really the personified forms of the disease. In the case of illness caused by sorcery it is really the *atua* of the wizard which gives power to the *karakia* or magic spell. And in disease due to infringement of the *tapu* it is the *atua* or malignant spirit sent by the tribal deified ancestors that is the actual cause of the malady. Thus, in former times, the vast majority of diseases were of the class *mate atua.*

The diagnosis of serious illnesses was made by means of the *hirihiri* ceremonies, to be described hereafter. It was thus found out whether the patient was the victim of the tribal *atua* or of *makutu* (sorcery).

GENERAL TREATMENT OF THE SICK.

When a native is taken ill away from his home it is the usual custom to carry him back to his own place, there to recover or die, as the case may be. Sick persons and bodies of the dead are so carried on litters (*amo,* or *kauhoa*), sometimes very long distances. The *kauhoa* consisted of two poles, between which the patient rested on a flax net with broad meshes, and wrapped in flax mats, the litter being carried on the shoulders of two bearers, one before and one behind.

Removal from one part of the country to another was, as Thomson points out, a favourite remedy for certain diseases, the object being to remove the patient from the sphere of action of the afflicting demon. This treatment was based on the belief that the power of the malicious *atua* was confined to a definite place—for instance, that of a deceased relative to the neighbourhood of his last dwelling-place, or the confines of the village. Another reason for carrying sick persons from one house to another, or to a neighbouring village, was to

have the continual benefit of the lamentations of the women. When a person is ill and the *tohunga* sees that the cause of his illness is located where he is residing, he tells him to go away to another place, and there live for a year or two: the trouble will not assail him there. This treatment, which is termed *whakahehe*, is suitable for illness due to *atua* or *makutu* (*i.e.*, demons or sorcery).

Sickness made a person *tapu* because of the *atua* or demon, *ngarara* or lizard, *kikokiko* or ancestral ghost, entering into the body of the afflicted. The sick were removed from their own houses, and had huts built for them in the bush, at a considerable distance from the *pa* or village, where they lived apart; if any remained in their houses and died there the buildings became *tapu*, were painted with red ochre, and could not again be used, which put the tribe to a great inconvenience, as some houses were the common abode of perhaps thirty or forty different people. In some cases, when the *tohunga* has divined that the disease is the result of an infringement of the *tapu*, and the patient is being punished by the gods for his wickedness, he banishes the victim, who takes up his abode perhaps in some miserable hut that cannot protect him from the evening breeze, much less keep out the dew and rain. Here he lies unattended, no person being permitted to hold further communication with him or to supply him with food. In some cases the sick person is compelled to lie out-of-doors on the ground, either without any covering or within a roughly prepared hut. At the present time a tent is often used, and some person remains in attendance on the invalid, but the attendance is of the poorest kind. Among the Tuhoe natives it is seldom, says Mr. Best, that one can detect any sign of affection for or loving care of a sick person, except sometimes in the case of children. No attempt is made to provide the sick with comforts of any kind. "I have often," he adds, "prepared food for sick people here, but find it necessary to take the food myself and watch the invalid eat it, otherwise he would see but little of it." Dieffenbach observed, however, that the Maoris with whom he came in contact provided the sick with better and more easily digestible food than usual—with cockles, fresh fishes, fish-broth, and game. The root or rhizome of the edible fern (*Pteris esculenta*), which is rich in starch and farinaceous matter, was also given to the sick.

The beliefs of the Maori relative to the origin of diseases had a powerful tendency to stifle every feeling of sympathy and compassion, and to restrain all from the exercise of those acts of kindness that are so grateful to the afflicted, and afford such alleviation to their sufferings. The attention of the relatives and friends was directed to the offended

gods and demons, and their greatest efforts were made to appease their anger by offerings, and to remove the continuance of its effects by incantations, charms, and mystic ceremonies. If their *karakia* rites and remedies were found unavailing, the *atua* (demons) were considered implacable, and the diseased person was doomed to perish. In such cases the Maoris treated their sick with rather more consideration and kindness than many other branches of the Polynesian race. It cannot be denied that the unfortunate sufferer was often expelled from the village and left to die of starvation, as was also the custom among the Hawaiians, New Hebrideans, Tahitians, and Savage-Islanders; yet we have no evidence to show that the Maoris ever murdered their sick, as was a common practice in certain Polynesian and Melanesian island groups. Thus, Ellis,* writing of the Society-Islanders, points out that these savages sometimes buried their sick alive. "When this was designed they dug a pit, and then, perhaps, proposed to the invalid to bathe, offering to carry him to the water, either in their arms or placed on a board; but instead of conveying him to the place of bathing they would carry him to the pit and throw him in. Here, if any cries were made, they threw down large stones in order to stifle his voice, filled up the grave with earth, and then returned to their dwellings." In other cases murder was perpetrated with heartless and wanton barbarity. "The spear or club was employed to effect what disease had been too tardy in accomplishing. All the persons in the house when these deeds of horror were performed were called out, and the friends or companions of the sufferer, armed with spears, prepared for their savage work. It was in vain the helpless man cried for mercy; instead of attending to his cry, they would amuse themselves in trying which could take best aim with the spear they threw; or, rushing upon him with spear in hand, they would exclaim '*Tui i raho*' (Pierce through), and thus transfix him to the couch on which he was lying."† Such barbarities as these are not, however, found exclusively among Polynesians, for in Russia the Tchuktchi slowly strangle aged members of the community, while the followers of Makaroff, in the Government of Saratoff, prematurely bury their sick relatives and friends.

LEGENDS CONCERNING THE ORIGIN OF DISEASE AND DEATH.

General.

To woman is attributed diseases and death. The following interesting note was sent to me recently by Mr. Elsdon Best. It refers to a subject on which our knowledge is ex-

* "Polynesian Researches," vol. iii., p. 49. † *Ibid*, p. 48.

tremely limited, and which is one of the fundamental beliefs on which the whole fabric of the Maori social system was built up—namely, the mysterious primal curse of woman or of the female nature. The ancient Maori held most interesting and unique ideas regarding the sexes, some of which are referred to here. "Tane said to Rangi, 'Where is the *uha?*' Rangi (the Sky Parent) replied, '*Kei raro te uha, te whare o aitua; e hamama i runga, ko te whare tena o te ora.*' Now, this remark has two applications. The *whare o aitua* means the female procreative organs (*tara, tore, &c.*), and is also applied to Mother Earth, because her children (man) die and are taken back to her bosom—*i.e.*, buried; also because of the mysterious primal curse of sex—female—which is ancient beyond compare, and appears in the most ancient myths of the ancient tribes of New Zealand. All troubles, misfortune, sickness, come from the *whare o aitua* (whence man enters the world)—*i.e.*, from the female sex. On the other hand, the children of the primal pair who remained on high (the sun, moon, stars, &c.) perish not, but live for ever. They represent eternal life, hence the term *whare o te ora* applies to them. The *ure tane* (penis), the sacerdotal term for which is *tawhito* ('the ancient one'), is another *whare o te ora*, or representative of life. The *tawhito* is the salvation of man: it gives *mana** to his *karakia* and saves him from sickness and death. A man clasped his penis while repeating *karakia* to ward off magic spells. The *tara wahine*, or female genital organs, were, as we have just pointed out, the cause of death entering the world. Maui entered the womb of Hine-nui-te-po (goddess or personification of death) *vid* the *tara*, in order to gain eternal life for man, but the *puapua* (sphincter vaginæ ?) of Hine closed upon Maui and killed him; hence death came to man. Thus the female genitals represent death, while the male organ signifies life. The first woman, in the Maori mythology, drags down her offspring to Po (night), meaning to death, and the first woman in the Greek mythology, Pandora, introduces all kinds of afflictions as an heritage for hers." The key to so many Maori customs and superstitions is to be found in their cosmogonic myths, and that portion relating to the creation of woman, and her fall, resulting in the introduction of death and disease into the world, may be briefly summarised here.

Commencing with a primitive state of darkness, night, morn, heaven (Rangi), earth (Papa), the winds, were produced in succession, and later Tiki, the first man. Rangi and Papa had numerous children, one of whom was named Tane-nui-a-rangi. This Tane, desiring a wife, made an image in the

* *Mana* = force, power, authority, &c.

human form from red clay. She was named Hine-ahu-one; and after giving birth to an egg, from which sprang all the birds of the air, Tiki-kapakapa, a girl, was born—the Maori Eve. Tane took her to wife, and she bore a female child. One day Tiki-kapakapa, who was now called Hine-a-tauira, said to Tane, "Who is my father?" On learning the truth the woman was sad, and fled away to Po, the lower regions of darkness. There she took the name of Hine-nui-te-po (Great woman of night). Her farewell words to Tane were, "Remain, O Tane, to pull up our offspring to day, while I go below to drag down our offspring to night." Thus was man cursed for ever and doomed to death. We have already related how the demi-god Maui visited Hine-nui-te-po to wrest from her, as she slept, the secret of eternal life, but she awoke and strangled the brave Maui. Since then all men have been subject to disease and death.

The *whare o aitua*, the passage by which man enters the world to be assailed by disease, by death, is seen in woman. As Rangi said to Tane, "The *whare o aitua* yawns below, the abode of life is above"; or, in the words of the ancient Maori priest, "That which destroys man is the *mana* of the female organ: it turns upon man and destroys him."

As affording a good illustration of the strange channels in which the thoughts of the Maori run, and as an interesting relic of an ancient system of phallic worship, the following remarks made to Mr. Elsdon Best by an old Maori may be here recorded: "Friend," said the old man, "it seems to me that the *ora* [health, vigour, vitality] of the white men, and their exemption from disease and sickness and premature death, is caused by their never forgetting the *koutu mimi* at night-time; it is ever in the room to protect them. For that urine represents the *tawhito*, and will avert any evil consequences of any act of witchcraft levelled against them. For that organ was the life and salvation of my ancestors, and saved them from trouble and death."

"According to Maori belief," says Best, "there were two most important things by means of which physical health and general well-being were retained. The first of these was the *mauri*, and the second *tapu*. To maintain inviolate the *mauri*, tribal, family, or individual; to refrain from transgressing the laws of *tapu*, and to retain his prestige and powers, natural and supernatural, was to command health, physical and mental.

"The tribal *mauri* is a sort of sacred talisman that holds and protects the health and prosperity of the tribe. The *mauri* of the Matatua tribes was located at Whakatane. It is termed the *pouahu*, or the *makaka*, by the descendants of the ancient inhabitants of the Bay of Plenty. This was the

supreme source of the welfare of the old-time people of the district, and through its power the sick were restored to health, or the cause of their death ascertained, and impending danger warded off from the living. The *mauri* of the later migration of Maoris from Hawaiki is known as 'the *manuka* at Whakatane,' a tree which is said to have grown from a branch brought from the fatherland. In the case of a sick person this *mauri* was appealed to by invocations repeated by the priest. The *mauri ora* at Whakatane was the salvation of man, says my aged informant; it was life and health itself; it represented the vitality and spiritual well-being of the people. The *manuka* at Whakatane was the essence and semblance, or personality, of health, of life, of spiritual and intellectual prestige.

"There was also a custom of instituting a *mauri* to represent the health and well-being of individuals, or of a family group, the latter being the real unit of Maori social life. In these cases some material token was placed at the *tuahu* or sacred place of the village, and this token or talisman was imbued with the semblance of health, vitality, &c., of the person or persons, and also that of the tribal lands. By means of this singular rite the welfare of man and lands was protected, and neither would then be in danger of suffering from the arts of the wizard. For, bear in mind, we are now speaking of sickness and troubles of divers kinds as being caused by magic arts.

"There were innumerable invocations used and rites performed in order to preserve the physical, intellectual, and spiritual vitality of man. These ceremonies began early in the life of the individual, when the *tua* and *tohi* rites were performed over the new-born child, and the *kawa-ora* and other invocations were repeated by the priest.

"When the *kumara*, or sweet-potato, was first obtained by the old-time people of Whakatane they were advised by the islanders from whom they obtained it to slay one Taukata and sprinkle or besmear his blood on the door-frame of the store-house in which the *kumara* was placed. This rite was for the purpose of preventing the *mauri* or life-principle of the tuber from returning to Hawaiki. Should it do so, then it would be useless attempting to cultivate or propagate the seed-tubers: they would not bear, the life-principle being departed.

"Now, the natives say that, in like manner, the *ora* (life, vitality, health) of the Maori people has returned to Hawaiki, on account of the *mauri* or *kawa ora* having become *noa*, or polluted. This sacred life-principle of man has become polluted through contact with Europeans—*i.e.*, the *tapu* of the race is destroyed. When Christianity was embraced by the natives they proceeded to *whakanoa*, or make them-

selves common, or free from *tapu*, that they might be able to accept the new religion. For the *tapu* was of the Maori gods, and must be got rid of, or reduced, so to speak, before the new god was accepted. This was done, in most cases, by washing the head with water heated in a vessel in which food had been cooked. Shade of Toi! It was enough to cause the whole horde of gods in the Maori pantheon to turn on the race and destroy it at a blow—the most sacred part of sacred man to be brought into contact with cooked food!

"As old Pio remarked to me, 'The *mauri* of the Maori has become polluted; that is what is destroying the Maori people. It may be that this generation, born among the white men, may survive, and be as healthy and virile and industrious. But I fear that the Maori has forsaken his own well-being [*ora* and *mana*] in pursuing that of the white man. And I ask, How may we survive? [*Me aha ra tatou e ora ai.*] Let us return to the beliefs of the Maori, and the rites of old. I am resolved to follow the practices of my forefathers, which have been followed for many generations. I say to you that the Maori is in fault; he has deserted his ancestral rites, customs, and beliefs, and now they have turned upon him and are destroying him.'"

The Tuhoe Maoris have a tradition that it was Irakewa, father of the chief Toroa of the Matatua canoe, who introduced disease into New Zealand from Hawaiki. He seems to have visited this country in some mysterious manner just before the coming of the Matatua canoe. Before the arrival of these voyagers it is said that disease was unknown here.

Violation of Tapu.

"The violation of *tapu* includes any interference with *tapu* objects, persons, or places. For instance, when a house has become *tapu* for some reason, and is deserted, it must not afterwards be entered, or burned, or interfered with in any way. Only a priest, or those under *tapu* for conveying a body or exhumed bones, may trespass on a burial-place or cave where bones of the dead are placed. Should any one else so trespass, then those bones of the dead will turn upon the intruder and slay him, or afflict him grievously. That is to say, the gods will punish that person.

"The bed and pillow of a *tapu* person are likewise endowed with that dread quality, and should any careless or imprudent person presume to seat himself on such, or eat food there, he will be seriously afflicted ere long. These things cannot be done with impunity. The gods will mark him down. This does not, of course, apply to the sleeping-places of ordinary persons who are not highly charged with *tapu*.

"To trespass on a *tuahu*, or sacred place where rites are performed, or any place where a sacred fire has been kindled, even though it were long years ago, will also bring down the anger of the gods. At no great distance from camp Heipipi, at Rua-tahuna, is an old settlement named Kiha, which has been deserted for nearly forty years. A few weeks ago, two native women in camp were discussing the probability of obtaining some flax from that place. An old woman said, 'Be careful how you approach that place. Do not go straight up through the clearing, but keep round the edge of the bush until you get opposite the flax, and then strike straight across.' 'And why should we not go straight up?' inquired one. '*He ahi kai kona*' (There is a fire there), replied the aged one. No more was said; the women understood at once that, in past generations, a fire had been kindled at that spot in order to perform some religious rite. They would carefully avoid the place.

"Another frequent cause of illness is the *kai ra mua*, a term applied to the act of eating food which has been set aside for the gods, or food prepared for a *tapu* person. It is also applied to the infringement of a *rahui* (a private *tapu* mark set up to prohibit persons from robbing or trespassing). There are many other acts of a similar nature the performance of which will cause a person to be seriously afflicted by the gods.

"*Tapohe* is a term applied to the polluting of persons, &c., by placing *tapu* objects in common places. The placing of the food, or remains of food, of a *tapu* person in a common place—*i.e.*, a place not *tapu*—would be a *tapohe*. If it happens to be the *maanga* (remains of a meal) of a sick person, the invalid will have a relapse, and the person who committed the dread act of *tapohe* will also be taken ill. If a sacred oven is *tapoheria* it spells death for the offender, unless he takes time by the forelock and hies him to the priest or a *matamua*, who may shrive him of his sin."

Affections of the throat were thought to be caused by the eating of sacred food, such as that prepared for the *tapu* persons who were engaged in burying the dead, or in exhuming the bones thereof. The disease inflicted by the gods for committing these breaches of the *tapu* are always considered very serious; by some they are believed to be incurable—the patient must die. And when death comes the body is burned, in order to protect other persons affected by the same disease.

Another method of slaying persons who have been guilty of *kai ra mua*, adopted by the gods, is to destroy them by means of a lightning-stroke. This is brought about by Tupai, one of the personifications of thunder. The form of

thunder represented by Tupai is accompanied by little or no rain.

The infringement of *tapu* as a cause of illness and death is still implicitly believed in by the Maori, and quite recently, at Gisborne, a *tohunga* named Paneri Tawera diagnosed the disease of his patient, Kapu, to be due to such a cause. He treated him accordingly; but, unfortunately, the patient died, and the medicine-man was charged with murder. Paneri stated the cause of Kapu's sickness in these terms: "The root of the sickness of Kapu is at Mangatu, at the site of the old *whare*. There is a pit there; Kapu has gone on to that place, and that is the reason of his sickness." He said that that was a sacred (*tapu*) place, and Kapu's sickness had resulted from trespassing on it. The *tohunga* conducted the relatives of the sick man to the scene of the trespass, and at the root of a poplar-tree found a stone, which, with some grass that was growing near, he carefully wrapped up in his handkerchief. He said, "This is the cause of Kapu's illness. A man in former times, coming from Ti Kete, on the sea-coast, arrived at this place, and they did not offer him any food. On that account he put a *tapu* on that particular place." The stone appears to have been the symbol of the *tapu*. After the *tohunga* had done talking the party returned to Koutara, where Paneri took the grass that was in the handkerchief and gave it to the people professing the same religion as himself, and told them to repeat certain incantations or charms. When they had finished their *karakia* he gave a bundle of grass to them. He directed that it should be placed secretly under the sleeping-mat where Kapu was lying. The only other treatment received by the patient in this case was an occasional drenching with cold water, the common remedy for fevers among primitive peoples. Poor Kapu died in great agony, and the *mana* of Paneri was shattered.

The *karakia* used by the Ngatiawa *tohungas* to cure those afflicted by disease as a punishment for trespass on a sacred place (*tuahu*), or a place where a sacred fire has at some time been kindled, or a cave containing the bones of the dead, is as follows. After the usual sprinkling process by the sacred pool or stream, the priest recites this incantation:—

Heuea ki runga, heuea ki raro
Heuea ki te po uriuri
Heuea ki te po tangotango
Tuhia mai te tuhi e atua nui
Ana ra e patu nei
Haere, whakataha ra Tutara kauika
Ana ra e patu nei
Haere i te po uriuri
Haere i te po tangotango

Rua koiwi
Haere ra i te po uriuri
I te po tangotango
I te wherikoriko
Ka kai koe ki to matua e tu nei
Mihia mai te tere nui
O te atua e patu nei
Tua mai te ora i tua
Koia nga atua e patu nei
Haere i tua, haere i waho.
Ko uru koe e patu nei
Haere i tua, haere i waho
Haere i te maramatanga
Atua nui koe
Haere i tua, haere i waho
Haere i te rangi nui e tu nei
Haere i te papa e takoto nei
Mahihi ora
Whakaarahia mai te kauae o te mate
Ara mai te hau o te ora
Kahu ana te tangata e patu nei
Haere i tua
Haere i te hau o tua, o waho, o te ora
Koia,
Koia nga tapu nei
Koia nga mate nei .
Koia nga atua nui e patu nei
E ara kahukura i te rangi nei
Haere nga atua whiu
Haere nga atua ta
Haere i tua
Haere i nga koromatua
Mahihi ora
Ki te whai ao
Ki te ao marama
Ko rou ora.

The *tohunga* and his patient then return from the stream, and the rite is performed to remove the *tapu* from them, during which the patient holds a dead coal taken from the sacred oven.

Disease Gods.

The mediæval physician and the astrologer of old believed that an intimate association existed between the heavenly bodies and those of men. The various organs of the human body were supposed to be governed by certain stars and planets of the Zodiac. Thus the heart was held to be in sympathy with the elements of the sun, the brain with the moon, the lungs with Mercury; or, according to one ancient physician, "Leo governeth the heart and causeth it to become afflicted; Cancer governeth the chest and lungs." The Maori regarded the stars as the *aria* (likeness, form of incarnation) of the gods; they were born of Tangotango and Wainui, and are the grandchildren of Rangi and Papa. The moon and sun are the elder brothers, the stars the younger brethren. "All

the stars are persons to us. The small stars are the common people." The heavenly bodies give signs to the people of the earth concerning the seasons, the crops, &c., and one star at least influences the bodily condition of human beings. When a person feels listless and weak (*iwingohe*) in summer-time it is said to be caused by Rehua—or, rather, by his summer wife, Whakaongekai. Rehua (Betelgeux, sometimes Antares) is also known and spoken of as "Rehua kai tangata" (Rehua, destroyer of mankind). Rehua is a chief among stars, a *whetu rangatira* (lordly star). Thus we have here the beginnings, the germs of astrological theories and beliefs such as those on which the whole fabric of medical practice was founded in mediæval times.

The Greeks had many gods to whom they appealed in times of disease, as, for instance, Apollo, Æsculapius, Diana, Hermes, Cheiron; several of these, notably Apollo and Diana, were also the senders of plagues and epidemics, disease, and death amongst men. We find that the Maoris also held similar views as to the existence of disease-producing and disease-healing gods. These divinities were anthropomorphic, or, in some instances, zoömorphic deities. They were not the fetishes of wood and stone which the zealous missionaries invariably and erroneously designated idols, for idols and idolatry were never existent, according to the best authorities, in Polynesia and New Zealand. The gods above referred to as playing an important part in producing disease were the national deities of the Maori race, and many of them were generally recognised throughout Polynesia. They were the great gods, mythical ancestors of the human race, the offspring of the primal pair Rangi and Papa, and denizens of the higher heavenly planes. They keep a jealous eye upon the people, the wicked inhabitants of mother earth, and were ever ready to punish them for infringements of the *tapu* laws of the national religion. It must be borne in mind that although in some instances the gods inflicted disease and death owing to the inherent maliciousness of their nature, yet generally pain and sickness were sent as punishment for sin. There are Christians who still regard disease in this light.

The Chaldæans, amongst others, believed that the different parts and organs of the human body were afflicted with disease by special gods or demons. Thus, one of their old manuscripts says, "The execrable Idpa acts upon the head of man; the malevolent Namtar upon the life of man; the malevolent Utug upon the forehead of man; the malevolent Alae upon the chest of man; the malevolent Gigim upon the bowels of man."

Similarly with the Maoris: various portions of the body were supposed to be presided over by different gods, to whom

were attributed the diseases occurring in those regions. Thus Tonga was the god of the head, and he produced headache and nausea; his abode was the forehead. Mokotiti, a lizard deity presiding over the chest and lungs, was the cause of consumption and pulmonary diseases. Tutangatakino, son of Tutewanawana, the father of reptiles, and half-brother of Tuatara, was the god of the human stomach. Titihai occasioned pains in the ankles and feet. Korokioewe produced the disorders of childbirth, and Taiepa, one of the inferior deities, assisted him in his wicked attacks on parturient females. Hineteiwaiwa, on the other hand, was the beneficent "goddess of parturition," who was always approached in times of painful or delayed labour, and one of the most ancient of Maori *karakia* (incantation) is that which they used when seeking her aid. She was also called Hina, Hinauri, Hinateotaota by the Maori, and is the most prominent of all Polynesian deities. Rongomai, who assumed the form of a whale, and on another occasion appeared in the heavens as a meteor or comet, with Tuparitapu or Tuparimaewa, the god of the liver, are responsible for consumption, and wasting away of the arms and legs. Paralysis and wasting sicknesses were attributed to the devouring influence of Hanake, sometimes called Niho-oa. Among the Tuhoe people, when a person has infringed the *tapu* by eating food in a sacred house, or by resting on a sacred pillow, revenge is taken by the god Te Hukita, who enters his victim's body and causes disease. Such a patient is taken to the nearest stream and sprinkled by the *tohunga*, who recites the *takutaku*:—

Ara to ara
Mehemea he urunga to take
Ko Te Hukita koe
Haere i tua, haere i waho
Haere i a moana nui
Haere i a moana roa
Haere i a moana te takiritia
Ki te whai ao
Ki te ao marama
Ka uru te ora ki roto
Ka uru te mate ki waho
Uru toro hei
He urunga koe e patu nei
Haere!
Te Hukita koe e patu nei
Haere ki o take
Ko rou ora
Ki te whai ao
Ki te ao marama.

In another similar *takutaku*, repeated over a person who had polluted the garments of a *tapu* individual by bringing cooked food near them, the words "*He kakahu koe e patu*

nei" are inserted, and after the words "*toro hei*" the *karakia* continues—

Tu tawake mai te atua i te rangi
Ka ripiripia
Ka toetoea
Ka haparangitia.

In such cases the *tapu* person whose sleeping-place has been contaminated can save the offender from the effects of his act by performing the above rite over him.

In times of epidemic sickness two gods in particular were called upon to stay the pestilence: these deities were named Mihimihitea and Tapatapa. The incantation to Tapatapa followed that to Mihimihitea.

In the following *karakia* the great national gods Rangi and Tu are invoked to cure the invalid:—

Breathe thou, breathe thou, O Rangi,
And thou Tu, give thy living spirit
To create life, that the body and soul may live in this world.
Beat with life thou heart.
The tree falleth, the tree of Atutahi;
Here the blow was given, the wind blew there;
There is the tree of enchantment.

The rainbow god, who is a disease-producing god according to the Zulus and the Karens of Burmah, is regarded by the Maoris as a beneficent deity. There is an old Maori proverb which runs thus: "*Haere, e whai i te waewae o Uenuku, kia ora ai te tangata*" (By going to the feet of Uenuku a man's life may be saved). Uenuku, also called Kahukura, Atuatoro, Tohaereroa, and Uenuku-Kopako, is one of the great or national gods—the god of life, death, and disease. *Karakia* were repeated to him by people who were ill.

Invalids also offered prayers to Kahui-tahi-o-rangi (Flock of warm ones of Rangi), who, though unable to heal sickness, exercised a mysterious power over man. Offerings of seaweed and grass were presented to them, so that they might be pleased and act kindly towards man.

In addition to the great gods above mentioned there are hosts of minor divinities, demons, animal gods, malignant *atua*, infant sprites, and wandering ghosts of the dead, who, from a spirit of mere mischief, or as agents of some higher divinity, or as familiar spirits of hostile sorcerers, enter the bodies of their victims, causing disease and death.

Disease Demons.

The Maoris very rarely attributed disease to demons. By "demon" I mean any supernatural being which is neither a god nor a disembodied human spirit. The New-Zealanders peopled their forests with numerous fairies and elves; but, unlike the Australians, they feared no fabulous disease-deal-

ing monsters such as Myndie, an enormous snake many miles long. who travelled over the tree-tops, and set up epidemics of small-pox and dysentery in the tribes, and caused ulcers and blindness.

Maori demons were for the most part aquatic monsters, like the Australian man-eating Bunyip and Wangul, which frequented water-holes. Thus we have the *taniwha*, a demon of huge proportions and terrible mien, inhabiting the lakes and rivers, devouring any human being whom he could capture. Of the sea demons, most dreaded was Mokoroa, the immense sea-serpent, many fathoms long. This mythical creature is one of the very few demons to which the Maori attributed diseases. Another was Ruamano, also an ocean monster, which, according to the Urewera tribes, caused the *mate pokapoka*, or diseases which eat into the flesh, such as various kinds of ulceration, ringworm, and a terrible disease of the face called *hura*, or *hore*.

In the good old days, before the advent of the *pakeha*, two very celebrated *taniwhas* resided near the bar of the Hokianga River. Their names were Tauneri and Arai-te-uru; and their very names were sufficient to strike terror into the hearts of the Maoris in that district. Tauneri was lord of all; Arai-te-uru was his subject, but by no means an obedient one, for he often on his own account entered the river, upset the canoes, and ate the eyes out of those whom he chose to drown—for this, be it known, was the *taniwha's* mark. Tauneri, being a *rangatira*, was not malicious: he only killed those who infringed his *tapu* or disregarded his *mana*. The *tohungas* alone had power to avert the evil consequences attending a visit to the home of these monsters, for they alone could repeat the *karakias* which must precede the visit. On one occasion four young men went fishing near the Hokianga Heads, against the wish of a powerful *tohunga*, whom they insulted, and jeeringly suggested that he might report them to his *taniwhas*. The deeply offended *tohunga* invoked Tauneri, and begged him to take revenge on those who scorned his power. Tauneri and his comrade capsized the canoe and devoured the wretched fishermen, and thus punished them for their temerity.

The lizards, spiders, birds, dogs, &c., which were credited with being harbingers of disease should not be classed with the demons, for almost without exception these creatures were regarded as the incarnations of ancestral souls, or of the lesser gods.

Throughout Polynesia one may say that disease was not frequently attributed to demoniac possession, but to ghostly possession and magic. Disease demons, such as those described in Assyrian, Accadian, and Hebrew mythology,

demons "born without father and mother, who are neither male nor female, who have not wife, nor to whom child is born," probably do not exist in Polynesian, Melanesian, or Australasian mythology or philosophy. The disease demons of the older civilisations are in the lower replaced by malignant human spirits.

Lizard Atua.

Certain species of lizards are greatly dreaded by the superstitious Maori, owing to the belief that these reptiles are the chosen abode, the *aria* or incarnation, of all kinds of evil and disease-inflicting *atua*. The ghosts of the dead, old and young, which had not been admitted to the underworld often became incarnate in lizards, and appeared before their living relatives as omens of impending disaster or death, or by crawling down their throats while asleep set up all manner of disease. The *kakariki* (*Naultinus elegans*), a beautiful bright-green lizard, about 8 in. long, is the variety generally chosen by the *kehua* (wandering ghost of the dead) for its earthly habitation. It has the power of contracting and dilating its pupil, and makes a curious noise which the Maori regards as malicious laughter, and the unfortunate person who hears the sound knows that he will soon die. The Tuhoe tribes regard the *tara-kumukumu* lizard as a malignant *atua* or demon, which, by entering the body, causes swelling or ulceration in the region of the thighs. This disease demon was exorcised by means of the *hirihiri* rite, in which would probably be some special reference to this reptile.

In addition to the lizards animated by *kahukahu* (miniature infant spirits), *kehua* (wandering ghosts of the dead) and tribal ancestral *atua*, who inflicted painful and wasting diseases on their relatives and enemies, either from pure malice, or as punishment for infringement of the *ritenga* or ordinances of the established superstitions, there were the lizard gods proper, descendants of the great primeval pair, Rangi and Papa. Thus Tangaroa, son of Heaven and Earth, and god of the ocean, had a son Punga, whose children Ikatere and Tu-tewehiwehi, or Tu-tewanawana, were respectively the male progenitors of all fish and reptiles. Tu-tewanawana, by his second wife, Tupari, begat Mokohikuwaru, the tutelary deity of lizards, and a god of evil whose dwelling-place is with Miru in Hades. Lower down the line of descent came the reptile deity Mokotiti, the god of pulmonary consumption and chest-diseases generally, and Ngarara, the disease-producer. Then, again, there were the mythical monsters called Mokoroa, serpents or lizards of immense size, which came across the sea from Hawaiki. In the following lament of a dying chieftainess her incurable illness is attributed to a demon of this latter class:—

Ah! this animal Mokoroa has
Thrust his teeth into my flesh, and
Grasped my body with his numerous
Teeth, and thus I am being eaten up.
The pain that wracks my body is like
An army passing on, each wounding
As he passes.
Aye, there's little
Hope of my recovery; I'm hastening to the dust
To appease the gods, who haunt my spirit hence.

If a traveller should see a lizard in the path before him, he would know the creature did not come there of its own accord, but had been sent by an enemy as an *aitua* (evil omen) for him to cause his death. He therefore at once kills the reptile, and gets a woman to step over it as it lies in the path. By this means the evil omen is averted. And he will also probably try to find out who sent this dread object to bring sickness or death to him. Then he will say, "May so-and-so eat you" Thus he will transfer the *aitua* to that person so named.

Ripia, the grandmother of the grand old chief Patuone, who died at Auckland in 1872, had a child stillborn, to whom was given the name Te Tuhi. He frequently troubled his tribe, appearing to them in the form of a lizard. His visitations caused great dismay, and many members of the tribe fell victims to his supernatural power. Tapua, the priest, offered prayers, and various incantations and divinations were resorted to in the hope of laying the troublesome spirit. It is stated that Patuone was urged repeatedly by the lizard spirit to become the medium of communication between the beings of the two worlds, but no amount of persuasion could induce Patuone to become the medium of the *atua*, and in process of time Te Tuhi's ghost discontinued to trouble his earthly friends.*

The Urewera natives thus account for their dread of lizards: Punga, the parent of all lizards, spiders, insects, &c., was also the origin of the *kumukumu* (gurnard), which elected to take up its abode in the ocean. As it went to the ocean the lizard sons of Punga said, "Soon we shall hear of you being roasted at a common fire." Said the *kumukumu*, "Ere long I shall hear of you being roasted in a fern fire." "Not so," replied the lizards, "for all will fear our ugly appearance." Hence, for all time, men have feared to look upon the lizard.

The *aria*, or form of incarnation of Tamarau, the Tuhoe chief, is a lizard known as the *kueo*, which resides in a *ti* tree at Rua-toki. It is the size of a *tuatara*, and bears whitish marks. Should any one approach its resting-place a loud

* "The Life and Times of Patuone," C. O. Davis, 1876, p. 15.

report is heard, and the *atua* is seen to dart away like a shooting-star, leaving the miserable spectator paralysed with fear.

Ngarara is the name of a lizard god, and is also the name of the disease supposed to be produced by this demon.

In New Caledonia, when a child tries to kill a lizard, the men warn him to "beware of killing his own ancestor."

Kikokiko *(Ghost Souls).*

There are two supernatural forces to which the Maori attributes most cases of sickness, especially internal or obscure cases, and these influences are—first, the presence of an ancestral ghost or *kehua*, and, second, the occult powers of the sorcerer or *tohunga*. The wandering spirits of the dead cause most diseases.

When a Maori dies, the *wairua*, or dream-ghost, or soul, which during life could leave the body and wander at large when its owner slept, becomes a *kehua*. "*Kehua*," says Best, "are the spirits of the dead which revisit their former haunts of this world and make things unpleasant for the living. *Kehua* appear to return to earth generally during the night-time—they dread sunlight and the light of fires. Some say the *wairua*, or ghost of a dead person, remains here as a *kehua* or *atua whakahaehae* until the body is buried; it then descends to Hades."

Kehua are said by some to be invisible, and capable of acting benevolently or in a hostile manner upon men. They can communicate with mortals; they eat and drink, wander about the village; they can see and hear what is going on about them. In fact, these disembodied spirits retain many of the characteristics of their living fellow-men.

Ghosts of the dead are invisible except to people who are asleep, or to priests in a state of trance. *Tohungas*, who possess clairvoyant powers (*matakite* or *matamatuhi*), sometimes saw a whole host of ghosts of the dead (*kehua*) traversing space. Such a company was termed a *tira māka* or *kahui atua*, and the object of their visiting this world was to acquaint living persons with the fact that some disaster or death was imminent. *Tohungas* would drive them away to avert the evil. It was a common thing for spirits of the dead to appear to their living relatives in order to warn them of evil. Should a person dream that he is chased by the ghost of a dead person, and the *kehua* from the Po (Hades) catches him, that is an evil omen; he may soon take ill and die. When a *kehua* appears to the *wairua* (dream-ghost) of a living person it is anthropomorphic, but when it appears at the request of its medium—say, at a spiritualistic seance—it assumes the form of a spider or lizard, &c. It can also make its appearance as a shadow of a sun-ray. Ghosts of the dead

were said to have returned to this world in the form of butterflies. In Samoa they are said to return in the form of moths. The Maori ghost, like the Australian, often revisits the spot where his bones are deposited. "Sometimes," said Beviuk, a New South Wales black, "the *murup* comes back to this world and looks down into his grave, and may say, 'Hallo, there is my old 'possum rug; there are my old bones.'" If a Maori trespassed on a burial-ground the ghosts of those interred there would punish him with disease, and perhaps death. Their presence is said to be made known generally by a whistling sound. A breath of warm air felt while travelling at night is a sign of the near presence of a *kehua*. *Irirangi* is the term applied to a spirit-voice heard singing without, when at night the people are within their houses: it is an omen of evil import. Shortland says the voice of ancestral ghosts is not like that of mortals, but a kind of sound—half whistle, half whisper. He had a conference with the ghosts of two chiefs who had been several years dead, and was assured that such was always the peculiar voice of *atua* when they talk with man. Other Europeans have had similar intercourse with Maori ghosts, and one need hardly explain that the mysterious voice was in every case the ventriloquistic utterance of the spirit's medium. I have already pointed out that the *kehua* become hungry like ordinary mortals, and Taylor states that they were thought to feed on flies and filth; but they also had the spirit of the *kumara* and *taro* (?).

When a Maori dies his *wairua* (soul) leaves the body, and either remains near the corpse or goes away to the lower world. In either case it can return, and, re-entering the corpse, bring it to life again. If the *kehua* goes to the nether regions it may be sent back to this world by its relatives, for the purpose of caring for its children who have been left without a guardian owing to the parents' death, but no soul can return to earth if in Hades it eats of the food of the denizens of that region.

The *tohungas* have elaborate ceremonies by means of which they restore the soul to a person just dead, but the feat is rarely performed, because the necessary astrological juxtapositions are rare favourable. The ancient Greeks offered the ghost fresh blood, that it might for a time be called back into life and answer questions—a conception which gave birth to the practice of raising the dead and asking oracles of them. By performing the *hirihiri* divination rite over a corpse the Maoris were enabled to consult the *kehua* or *wairua* of the dead person, and gain information as to the cause of its death. I have already referred to the hosts of ancestral ghosts sometimes seen by the *matakite* or

clairvoyant seer: these companies of spirits were called *apa hau* by the Tuhoe people, and they were represented in the living world by some living relative, who was the medium (*kauwaka* or *kaupapa*) through which such spirits communicated with, and acted as guardians of, their living relatives. A single person may be the medium of the *kehua* of many deceased relatives. Such *kehua* or *wairua* do not abide with the medium, but visit him when they have anything to communicate. The medium may be quite a common person, of no standing in the tribe until he becomes a medium.

Ancient Greek philosophic thought ran to some extent in grooves parallel with that of the Maori. Thus the Greeks believed that the soul left the body and assumed animal form. In particular the snake was imagined to embody a soul; but the forms of bats, birds, and butterflies were also assigned to the spirits of the departed. The Greek ghosts, like the Maori *kehua*, kept the human form, and to them were ascribed all the attributes of living persons. Food was offered to them; ceremonies and rites were performed to appease their wrath; their influence was exerted only in the neighbourhood of their abode; they revealed future events, or the proper remedies for sickness; they avenged neglect by sending sickness or death, and were therefore called *kereo* (*cf.* Maori *kehua*)—in short, the Greek conception of the ancestral spirit resembled almost in every particular that of the untutored Maori.

I have dwelt at length on the nature, modes of manifestation, and special characteristics of the *kehua*, or ancestral ghosts, because they are in many ways the counterpart in primitive medical systems of the pathogenic bacteria, or disease-germs, of modern medicine. The Maoris, and, in fact, man in all stages of evolution, from crude savagery to hypercivilisation, regard ancestral souls as playing a most important part in the causation of disease. At the present day the followers of Blavatsky and Besant attribute disease, like the Maori, to the *kehua* or ghost of the dead. Such was also the belief of the Hebrews, Egyptians, Greeks, and Romans; and this theory still holds a prominent place in the medical lore of the Polynesians, Melanesians, Australian aboriginals, the Amazulu, Peruvians, and European peasants, especially in Russia, Germany, Austria, and Sweden. In India, China, and Japan we find similar ideas. It was not until the reign of George II. that the statute of James I. of England enacting that all persons invoking any evil spirit, or consulting, covenanting with, entertaining, employing, feeding, or rewarding any evil spirit, should be guilty of felony, and suffer death.(?)

According to Maori belief the ancestral ghosts confined

their attentions to the tribe to which they belonged, inflicting or curing disease in their living relatives, or in other ways exerting their powers for good or evil among them. The *kehua* of a dead person is known by the name of such a person. The most malignant of the *kehua* were the souls of still-born children and the *paheke* spirits, which form a special class of evil beings called *kahukahu*. Ancestral ghosts are the tribal and family *atua* or gods, as distinguished from the national gods, such as Rangi, Tu, Tangaroa, &c. The question then arises, why do the tribal *atua* or ancestral ghosts inflict disease on their living relatives? And the answer briefly is, because of neglect on the part of the living to pay proper respect to their dead. In other words, the *atua* inflict disease because the living relative has broken a religious commandment, or *tapu*, and thus insulted some ancestral spirit. Then, again, Maori sorcerers often had certain *kehua* or *atua* at their command, and by suitable incantations, such as the *mata-tawhito*, they could collect these good genii round them to keep off evil spirits; but, on the other hand, they were able, by means of other *karakia*, to send these ghosts on disease-inflicting errands among other members of the tribe. Evilly disposed persons would sometimes invoke an ancestral ghost (*kehua*, or *atua*) to slay people of the world of life without just cause. In one case of this kind the ghost was armed with a *taiaha* by the invoker and instigator, and was seen bearing the *taiaha* (weapon of war) and searching for some one to slay. One valiant person challenged it, axe in hand; the ghost fled to the burial-ground and disappeared into a grave.

In some cases the *wairua* of the dead were invoked by means of *karakia*, in order that they might avenge a murdered person. For this purpose the body of the murdered person is laid on the sacred place (*tuahu*) of the tribe, and the priests invoke the aid of the *kehua* of the deceased, who, having given some sign of his presence, receives instructions as to whose death is desired. Then the body is buried, and ere long his murderers take sick and die.

Should a person desecrate a sacred place of the tribe, such as the *tuahu* or *ahi taitai*, he will certainly be afflicted by the ancestral ghosts (*atua*) in a most grievous manner. Of if he desecrate a tree which has been *tapued* by the *tohunga*, and thus set apart for some special purpose, such as bird-snaring, he will be assailed by the familiar spirits of the priest, and, although he may not die at once, yet he will gradually succumb. It is not an uncommon practice to make a person offend against some law of *tapu* without his being aware of it, with the express object of causing the anger of the *atua* to fall on him. This practice is a class of witchcraft (*makutu*). If the body of a relative, or any person of the same tribe, is

eaten, then the ghost of the same would inflict sickness and death on the eaters of his body. It is safe to eat the body of a person belonging to another tribe, because, as I have already pointed out, the ghost or *atua* of such a person cannot inflict disease on those not related to him. It is interesting to note that the *atua* are not supposed to inflict disease always on the person who breaks the *tapu*, but, as Shortland says, more generally on the sacred person himself whose duty it was to guard himself from such an indignity. This refers especially to the *tapu* law, which prevents a common person eating food which has touched the person or clothes of a priest or chief.

A person knows when a ghost has entered his body by the creeping sensation felt in the flesh of the arms or other parts of the body at the moment the *atua* enters. This symptom is termed *papakikokiko*.

Diseases attributed to *kehua* have applied to them the generic term *mate kikokiko*, and the ancestral ghosts who cause such diseases are called *kehua*, *wairua*, *atua kahukahu*, *kikokiko*, or *atua kikokiko*, and as a class are designated *atua poke*, or malignant spirits. Of these, the most utterly *poke* were the *kahukahu*, a term applied to ancestral ghosts, but perhaps more commonly restricted to menstrual germs which have become malignant spirits, and to the ghosts of prematurely- and still-born children, the most dreaded of all disease-germs.

Atua poke were liable to visit their victims at midnight, and set up painful bowel complaints, fever, insanity, and numerous other painful and fatal diseases, often of a lingering character, and resulting in great wasting of the body. As already pointed out, a near relative was often the subject of their wrath. The ancestral ghosts of Australian blacks gave disease by such simple means as the thrusting of twigs and small pieces of wood into the eye or the ear; or, creeping up to the victim, would extract his kidney-fat; or would kill him by inflicting blows on the back of the neck with an invisible club. "It was by no means an unusual thing for Morioris to affirm that they had been visited by the *kikokiko*, in which case, at the slightest approach of sickness, they would resign themselves to death, and that would be the invariable result."

The question next arises, why did ancestral ghosts wander about as malignant spirits? Had the Maoris no means of "laying" the ghosts? It is well known that the ancient Greeks resorted to all manner of religious rites and festivals of the dead to prevent the "destructive ones" from returning to earth and causing illness and death. The Melanesians make offerings of food to the *duka*; the Samoans offer libations of *kava* to keep the ghosts friendly, and in times of war kinswomen of the dead visited the theatre of death carry-

ing mats. The place of death was earnestly sought out; the mat was spread upon the ground, and the women sat about and watched it. If any living thing alighted it was twice brushed away; upon the third coming it was known to be the spirit of the dead, was folded in, carried home and buried beside the body, and the ghost rested. But for this the spirit would wander about and be unable to gain an entrance to the proper country of the dead. Australian natives resort to many ingenious practices to prevent the ghost from leaving the grave after burial. They sometimes remove the finger-nails of the deceased so that the spirit may be unable to scrape a hole in the earth and thus escape; or, to gain the same end, they tie the fingers tightly together with cords, or the finger-tips are burned. In Thibet they pierce the soles of the feet and also the heart of the deceased, thinking that, being nailed into their tomb, the spirit cannot possibly leave it. Hunt, writing of the Moriori, says, "The everlasting *kikokiko* was a terrible bugbear to old and young; they had a firm belief that a person visited by an ancestral ghost, and touched on the head, would die very soon after such visitation. To prevent the dead from troubling them they had a very curious custom." When a person died they would all assemble at midnight in some solitary, secluded spot and proceed to "lay" the ghost. "First, kindling a large fire, they would sit round in a circle, each person holding a long rod in his hand; to the end of each rod a tuft of spear-grass was tied; they would then sway their bodies to and fro, waving the rods over the fire in every direction, jabbering away strange and unintelligible incantations."

The methods adopted by the Maoris to "lay" the ghosts of the dead varied in different tribes, according to the local theories regarding the soul's destiny after death. Maori philosophers were divided in their beliefs as to the destiny of the soul after death. Some held that the soul remains on earth; others that it descended to Hades (Te Po); while a third school believed that the human spirit finally ascended to the blissful heavens of Rangi.* Thus many of the Taranaki natives had no faith either in the ascending or descending of spirits: they thought that the dead always remained near their bodies; that the *wahi tapu*, which are generally small groves adjoining their *pas*, in which they were interred, were also filled with their spirits; but if a person died a violent death, he wandered about until the priest, by his incantations, brought his spirit within the sacred enclosure. An old philosopher of the Tuhoe tribes, one of the Hades school of thought, thus addressed Mr. Elsdon Best: "Son, our ances-

* This is modern.—E. B.

tors never taught us that Rangi, our parent, issued a command or law that his descendants [man] should ascend to him at death. The word of Rangi to Papa [the Earth Mother] was this: 'Our grandchildren, foster them; conceal them, let them be hidden in the deep darkness in the bowels of the earth.'" In other tribes, however, it was held that the souls of chiefs and *tohungas*, at least, ascended to heaven (Rangi). And at death *karakia** were addressed to Tawhaki "so that the spirit of the deceased might ascend to heaven, Tawhaki's abode."† The officiating priest, while repeating his "ghost-laying" invocations, held a staff, the end of which he placed on the heart of the deceased.

The prophylactic measures adopted by the Taranaki natives naturally consisted in burial rites and ceremonies for the purpose of inducing the spirits of the dead to enter the sacred grove, and, being safely deposited there, to prevent their escape. Thus, when a chief was killed in battle and eaten, his spirit was supposed to enter the stones of the oven, which retained their heat so long as it remained in them. His friends repeated their most potent incantations to draw out his spirit from the stones and induce it to enter the sacred grove (*wahi tapu*). So, also, when any were slain in battle, the friends endeavoured to procure some of their blood, or fragments of their garments if the body could not be obtained, over which they uttered *karakia*, and thus brought the wandering soul within this spiritual fold. These places were looked upon with much fear, as the *atua* are thought occasionally to wander from them, and cause all the sickness their relatives suffer. In them the *tuahu*, or native altar, the *toko* and the *pataka*, or stage of offerings to the *atua*, were placed: it was thought to be extremely dangerous for the living to enter them or the *tapu* houses where the dead were buried. Thus we have here a cult of the grove, or cult of the grave, and a care of the dead as a protective measure against sickness and death.

Those who believed that the soul went at death to the dark underworld, to Te Po, Te Reinga, Paerau, or Hades, did not neglect the necessary ceremonies to induce or to enable the *wairua* of the dead to gain admission to that abode of the dead. These rites and incantations were called *tuitupapau*, and by observing them the ghost was effectually "laid," but if neglected it became an *atua kikokiko* and a source of danger to the surviving relatives. The god Tiki, creator of man, guards the portals of Hades; he sits at the threshold of his long reed house in Te Po, and forbids the ghosts of the

* See Taylor, "Te Ika a Maui," p. 101.
† C. O. Davis, "Patuone," p. 135.

departed to enter unless the friends of the deceased have performed the necessary ceremonies and made offerings of food. Taylor relates an instance where a child was buried, and after a time the bones were disinterred, scraped, placed in an ornamental basket, and suspended from the ridge-pole of the *mahau*, or verandah, of the father's house. From time to time the *tohunga* repeated *karakia* over them, to assist the soul in ascending through the different heavens. Every time an incantation was uttered over the bones it was supposed to aid the soul in its ascent.*

Such, then, are some of the methods by which the Maori sought to prevent the souls of their dead relatives from developing into *atua poke*, or disease-dealing *atua*; and doubtless the weeping, singing, food-offerings, and dances at the *tangi* preceding the *nehunga* or burial were also to propitiate the *wairua* of the dead.†

When a person believes he is afflicted by an ancestral ghost he hurries to the *tohunga*, who will, after sunset, take him to the sacred pool (*wai tapu*) and cause him to stand naked in the water. The *hirihiri* or diagnostic rite will then be performed, and the *tohunga*, having decided what caused the sickness, will pull up a fern-stalk (*rarauhe*) and, dipping it in the water, sprinkle the holy water over his patient's body, at the same time exorcising the demon by means of suitable charms or *karakia*.

If the person recovers he will probably become the *kauwaka* or medium of that evil *kehua* or ghost, and enjoy the power of being able to afflict his enemies by means of the supernatural powers of the spirit.

The Kahukahu.

The *kahukahu* constitute another group of very malignant disease demons. They are the spirits of still-born and immaturely born children, and ghosts which spring from menstrual clots (*paheke*)—the latter are thought to be wasted souls of human beings. These belong to the great class of spirits called *poke*, the *atua poke* being unclean, wicked, man-destroying sprites. Their chief delight is to get into human bodies and cause most painful diseases by biting and pinching the sensitive internal organs.

The Maoris have various beliefs regarding the precise source from which the human soul, or life, takes its origin. Some say "the moon is the real husband of all women, and the marriage of man and woman is of no moment"; while

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* From Taylor's "Te Ika a Maui," a most unreliable work. For the trail of the missionary is over it all.—E. B.

† No; to avenge the death.—E. B.

others declare that the *hau* and *wairua* of a child are implanted during coition, by the father, the mother being merely a receptacle (*whare moenga*). When this soul, whatever its origin may be, is prematurely liberated from its *whare moenga* it becomes a *kahukahu*.

The idea of woman being the repository of potential *atua poke*, and the menstruating female as a liberator of malignant *kahukahu*, led to the imposition of certain restrictions on women, and to their segregation during the menstrual period. (?) Thus, "a Maori woman may not step over a male child, or it will be stunted in growth; nor may she step over a man, should he be lying in the way, though in the latter case it would be merely looked upon as an act of impertinence." Then, again, should a person inadvertently seat himself on a place used by women as a seat or sleeping-place, he will lose his acuteness of vision as a seer of the supernatural. Should a warrior or seer lie down in the women's portion of a house he will become *kahupotia*, or afflicted by *tu-matarehurehu;* his sight will become dim, his pluck decrease; he will not be able to distinguish an enemy or see the *atua*. To avert this calamity he must perform the *whakaepa* rite, that the mind and the eyes may be clear.

During menstruation the woman is *tapu* and is avoided by others. She uses a diaper, or some special form of apron, called *marototo*, *remu*, *korea*, *whakatahe*, *angiangi*, or *kahukahu*,* within which the infant sprite is supposed to remain, for a time at least, and which was usually placed, after use, amongst the reeds or rushes forming the wall of the *whare*. Here these *atua* dwelt, and were sometimes called *atua noho-whare*, or house-dwelling demons. In some localities it was customary to bury the menstruous diapers "in a proper manner and with appropriate ceremony, that the *kahukahu* may be laid or rendered powerless to assail those who dwell in the living world. This is done by the all-necessary *tohunga*, who, having cooked some food in a sacred *umu* (earth oven), proceeds to offer it to the gods, and then by means of *karakia* (incantations) he renders harmless the evil spirit or germ." The spirit of a *kahukahu*, according to Tuhoe belief, "will sometimes enter a fish, or a moth, or a pig, according to where the *whakatahe* is thrown (the safest plan is to bury it deeply). If left on the surface of the ground it may be eaten by a pig, or a moth may fly over it, and then that pig or moth would be entered by the spirit of the *kahu* and so become a malignant demon, an *atua ngau tangata*, a demon to assail man. If thrown into water and found by a fish, that fish will become an *atua*, a demon pos-

* These terms are somewhat mixed.—E. B.

sessing grievous powers. In this (Tuhoe) district a fœtus was buried under the perch of a tame *kaka* bird, and the spirit or *cacodemon* of the same entered the bird, and worked much harm to man. And should a person dream that he saw the bird with its feathers ruffled, or upstanding (*e whakakenakena ana*), that was a good sign—the sick person would recover. But should the bird be seen (in a dream) to wriggle about (*a kia mohimohi ranei nga huruhuru*), that was a bad omen for the invalid. Affections of the eye and other ills are said to have been caused by that bird."

Mere contact with *paheke* blood was sure to infect a person and to result in the victim becoming possessed by an *atuakahu*.(?) Breaking the *tapu* also provoked the *atua* of the family to anger, and led them to punish the offender by sending infant sprites to feed on a part of his body, more or less vital, according to the magnitude of his crime. Infant ghosts, it seems, are generally selected as the agents of the vengeance of the family *atua* (*i.e.*, deified ancestral spirits), on account of their love of mischief, and because, not having lived long enough on earth to acquire attachments to their living relatives, they are most likely to attack them without mercy. The *atua* or ancestral ghosts were the only sort of divinities supposed to take an interest in human affairs, and were very jealous of any neglect of the duties enjoined by their religion. Their instruments of punishment, the *kahukahu*, were greatly dreaded, in proof of which the following lines may be cited :—

Ko te kahukahu piri-tara-whare.
Kei te whakaheke au i aku toto,
Wai tuhi-rae no nga tohunga.
Nana ka ngau kino, ka mate rawa.

which may be translated thus :—

It is the *kahukahu* sticking fast in the wall of the house.
I am making my blood run down,
Instead of water, to smear the brow of the sorcerer.
Should he (the *atuakahu*) gnaw spitefully, *it will be certain death.*

In the event of a person being afflicted by a *kahukahu*, he may be cured by the first-born (*ariki*) of the family, who accomplishes this by biting the part affected. Or, by means of the *hirihiri* rite, the priest may ascertain that a certain woman is the cause of the trouble. He then questions her : " Is there nothing that you know of?" She will reply, " I had a clot of blood, and threw it into the water." Enough ! The priestly seer goes off to search for the plant or moss termed *keketuwai*, to be used as an *ara atua* (a path for the god) by which to expel the demon. He places the weed on the afflicted one, and recites this *karakia* :—

Tenei to ara
Haere ki ou tupuna
Haere ki ou matua
Haere ki ou koroua
Haere ki nga mana o ou tupuna.

Water-weeds, such as the above, were often used as *ara atua*, by which route the afflicting demon would be forced to depart. The weed or leaf used would then be deposited in the sacred place of the village.

The following is another form of *takutaku*:—

Hurahia ko te tutu
Hurahia ko nga atua
Ma wai e huaki?
Maku e huaki
Ka matika, ka haere
Tau tika, tau tonu
Te roua atu, kapea mai
Roua ki whiti, roua ki tonga
Hamama tu te waha o nga atua
I titaha te taha o te rangi
E oho nga atua whiu
E oho nga atua ta
E oho i te rawa i pakina ai koe.

This calls upon the gods or spirits afflicting the person to give some sign of their presence when the particular cause of the attack is pronounced. The *tohunga* then goes on to mention various *tapu* objects, and when the patient sneezes, or yawns, or gasps, the object then being spoken of was the cause of his illness. The medicine-man, having thus diagnosed the nature of the complaint, then proceeds—

Haere i te pu
Haere i te more
Haere i te weu
Haere koutou e patu nei
Haere i tua, haere i waho

Or, if it is an *atua kahu*, then he inserts,—

Atua kahukahu
Haere i a moana nui, &c.

The *tohunga* will also proceed to the place where the fœtus was buried and there kindle a fire, over which he will repeat an incantation in order to lay the evil spirit and to render it harmless. He will also cook some food, usually a *kumara*, or sweet-potato, at that fire. This he proceeds to eat, and thus the evil spirit is *tamaoatia*, or polluted, rendered harmless. This rite is nowadays termed *whakawhetai* by the Tuhoe people—a modern, introduced expression.

The above rite was often performed over the fœtus as soon as it was buried, in order that the evil spirit might be rendered impotent, otherwise it might turn on the relatives of the woman and afflict them sorely.

To destroy the evil spirit of a human fœtus, some of the leaves in which food has been placed for cooking may be used as a covering for such fœtus when buried. This will have the desired effect. There is nothing so inimical to *tapu*, or supernatural powers, as cooked food, or anything which has come into contact with it.

But in some instances these *atua kahu* were not destroyed, but were cultivated, conciliated with offerings, and developed into war gods, in order that their power might be directed against tribal enemies. Such was the origin of the *atua* known as Te Awa-nui, Parehouhou, Peketahi, and Te Rehu-o-Tainui, of the Tuhoe Tribe.

Another kind of demon which caused disease was the *rikoriko* or *ngingongingo*, which haunted deserted houses and ruins of villages. They would creep into the bodies of unwary mortals and devour their vital organs. The Tahitian word *riorio* means "the ghost of an infant," and perhaps these *rikoriko* were *atua noho-whare*.

Makutu (Magic).

Maori mythology contains several accounts of the origin of sorcery. In one of the cosmogonic myths it is related that the visible heavens combined with the great abyss of eternity to produce the numberless sorceries, the gods Taokaimaiki, Taoitia-paekohu the enduring, and other numberless forms of witchcraft, and the "cold of space." The sorceries and the "cold of space" combined are the destroyers of mankind. "From the heavens originated all calamities." Another myth relates how the great hero Maui enraged Rohe his wife, who "was beautiful as he was ugly, and on his wishing to exchange faces with her she refused him his request. He, however, by means of an incantation, managed to gain his point; in anger she left him, and refused to live any longer in the world of light, but proceeded to the underworld and became a goddess of Hades" (Tregear). A variant of this myth is that Rohe was killed by Maui, and her spirit, returning from the shades, in revenge killed him; "hence death, witchcraft, and all the evils men are subject to came into the world." Other charms and spells, witchcraft, religious songs, and dances, were obtained from Miru, the goddess guarding the Gates of Death, who dwelt in Hades, and who was visited by Rongomai, a celebrated demi-god ancestor of some of the Maori tribes, to whom she imparted, amongst others, the *kaiwhatu*, a "guardian charm" by which witchcraft was averted. One of Rongomai's men was caught, and was claimed by Miru in sacrifice as *utu* (payment) for having taught the sacred knowledge, but Rongomai and the others returned safely to the world again.

Maori legend abounds with fabulous stores of the magical powers possessed by ancient *tohungas;* how Kiki, a celebrated sorcerer of Waikato, was so endued with *mana* that his shadow withered the grass and shrubs when he travelled abroad; how Tautohito and Purata, two celebrated wizards, possessed a magical wooden head, and slew hundreds of persons by the power of its enchantments.

Diseases attributed to Makutu (*Sorcery*).

Like all other primitive peoples, the Maori believes implicitly in the potency of the dread incantations and mysterious rites of the sorcerer. By appropriate *karakia* the ghosts of the dead (*kehua*) are sent by the *tohunga* to enter his victim's body and afflict him with disease. Or, without the intervention of any disease demon, by mere repetition of charms and performance of symbolic rites, the occult power, or *mana*, of the wizard may accomplish the same end. In the latter case the victim is often warned that he is bewitched, and such magical arts prove effective through the patient's own imagination; when he knows he has been subjected to *makutu* he will often fall ill, and will actually die unless he can be persuaded that he has been cured. Disease and death by magic may be effected in still another way—by destroying the victim's *wairua* or dream-ghost; the *ahua* or semblance, or its *aria* or form of incarnation, being acted on by the *tohunga* in a manner elsewhere described. The *hau*, or intellectual spirit, also may be destroyed by means of a bait, or *ohonga*, which, in the form of some hair, spittle, or article of clothing of the intended victim, is supposed to contain the *ahua* or semblance of that essence, called *hau*, which pervades and vivifies the body.

The idea that the sorcerer can capture the *wairua* (dream-ghost) of an enemy, and by killing it can thus kill his victim, though commonly met with throughout Polynesia, is not often met with in New Zealand.* Thus, in the Sandwich Islands, there was a special class of *tohungas* called soul-catchers (*po'i uhane*), and they were not only able to see the souls of living beings, as were the *tohunga kilokilo uhane*, but could catch them with the hand, and squeeze them to death, or imprison them in a water-calabash. The sorcerer then had the owner of the soul in his power, and could levy blackmail on him as he pleased, for if he killed his *kakaola* he would go into a decline and soon die. In the Solomon Islands if a child starts in its sleep it is believed that some ghost is snatching away its soul. In New Britain disease is sometimes attributed to a certain *atua* having seized

* It was an universal belief among the Maori.—E. B.

on a man's dream-spirit or soul and bound it to a tree. The priest takes a fish or pig to the sacred place and offers it, saying, "This is for you to eat in place of that man; don't kill him"; and he is then able to loose and take back the sick man's soul so that he may recover. At Uea, one of the Loyalty Islands, it was the custom formerly when a person was very ill to send for a medicine-man whose employment was "to restore souls to forsaken bodies." The soul doctor and about twenty assistants would repair to the family burial-ground. The male assistants then played nasal flutes, while the women assisted by a low whistling supposed to be irresistibly attractive to truant souls. The soul was then conducted back to the village amidst great rejoicing, and was ordered in loud tones to re-enter the body of the sick man. So also among the tribes of the Lower Congo we find the same peculiar belief that in cases of chronic illness the spirit (*moyo*) of the sick man is supposed to have left his body and is wandering at large, and the aid of the charm-doctor is called in to capture the wandering spirit and bring it back to the body of the invalid. In Fiji a sick native has been seen lying on his back bawling for his soul (New Zealand, *wairua*) to come back; and in another case a native declared that his soul had left him, and he was therefore a dead man. After chatting with his relations, and having a hearty meal, this man who believed himself to be soulless was carefully buried. Thus the conception of disease being due to the absence of the *wairua*, or dream-ghost, or soul, from the body is commonly held by Polynesians, Melanesians, &c., but it is not often met with in New Zealand. The Maori sorcerer endeavours to take or operate on the *hau* in order to destroy the *wairua* or astral body. It is true that in the *rua torino* and *rua-iti* ceremonies the *wairua* is destroyed, and with it, of course, the earthly body wherever it may be. And the high priests of old frequently used an incantation called *haruru* in order to destroy the *wairua*, and thus set up a fatal illness in the material body. Generally speaking, however, the Maori did not attribute disease to the absence of the *wairua*, and the machinations of the sorcerer were directed against the *hau*, not the *wairua*.

The *wairua* is supposed to be able to see and hear, and leaves the material body during sleep, but apparently not when the person is awake, as in Polynesia it wanders forth as a spy to find out if any sorcerer is trying to bewitch its owner, and returns to warn its physical basis, and *hau* or life-essence, if the magician is afoot. The *wairua* is an active defensive astral body; the *hau* is a passive element which pervades the material body, and when acted on by those who practise *makutu* causes illness or death of the victim. Much of Maori magic (*makutu*)

is based on their conception of the human *hau*. The *hau* is a vital essence which cannot, like the *wairua*, leave its physical basis, the body. Parts, however, may become detached when one walks or sits down, and on this fact is based certain sorceries belonging to the category of sympathetic magic.

This sympathetic magic, which is so commonly practised by the *tohunga makutu* of New Zealand, worked on the supposed vital connection between the object (*ohonga*) and the subject (human *hau*). The victim is supposed to be in sympathy with the bait (*ohonga*), and sickens and dies as it burns, melts, or rots. The first essential, then, in practising this form of *makutu* is the *ohonga* or bait, which is the *ahua* or representation of the *hau*. The bait, as already stated, must be some object which has touched the person to be bewitched, such as a drop of spittle, some hair, paring of finger-nail, shred of clothing, remnant of food, some earth on which the victim has sat or walked, or even a drop of blood, as in the classic case of Maui. Having obtained the material medium, it is converted into an *ohonga*, when the appropriate incantation is repeated over it. When this *ohonga* is obtained the sorcerer ties it to a piece of the *karamuramu* (shrub used in mystic rites). He then carries it to the sacred grove or village altar and invokes his own or the tribal *atua*. The cryptic *karakia* repeated over the bait makes the victim sicken and die. When taking the bait from the person a *karakia* suited to the occasion must be repeated. The bait, says Best, is the passive agent; the incantation which destroys the *hau*, and through it the physical body, is the active agent. In Melanesia and some parts of Polynesia, however, it would seem that the bait is an active agent, for as the bait melts or rots or burns so does the victim become feverish or ill. When no incantation is employed, as in some instances in certain Australian tribes, then the bait becomes the active agent of sympathetic destruction.

Sympathetic magic was practised by the great Maori gods For instance, Hine-nui-te-po destroyed Maui by this kind of sorcery. The bait used was a drop of Maui's blood. Hine sent in succession the butterfly (*kahukura*), the mosquito (*waeroa*), the midge (*tuiau*), and the sandfly (*namu*) to secure for her the necessary *ohonga*, and the last succeeded in obtaining it after the others had failed.

A favourite bait was saliva, because there was not generally much difficulty in obtaining it. The Urewera, famed all over New Zealand for their skill in *makutu* practices, often used spittle as a bait. For this reason, people are careful not to spit when in company with members of this tribe. So great was the dread of sorcery in the Sandwich Islands that the kings used always to have near them spittoon-bearers, and these people

carefully disposed of the spittle, either by secretly burying it or throwing it into the sea. Remnants of a repast were also used as a bait, and after having spells pronounced over it was buried. Food could also be bewitched during a meal by merely quietly repeating a charm as the victim ate. Or the food could be bewitched beforehand by means of *karakia*. He who ate such food which had been rendered *tapu* would be punished by *atua* with sickness. Such cases are not, however, instances of sympathetic magic. A man's clothing is permeated with his *hau* and makes an excellent bait; so also, but to a lesser extent, is the earth which bears a foot-print, and a seat on which one has been sitting. If suspicious of the *hau* being abstracted for purposes of *makutu* he will, as he rises, touch the seat with his left hand and scoop up the invisible portion of *hau*. In the good old days, persons travelling through a hostile country would walk as much as possible in water, so as to avoid the danger of having their *manea* (*hau* of the human foot or foot-print) taken. Should a sorcerer chance to come upon your trail and extract your *manea* from your footsteps, and take that *manea* to his abode and suspend it on the *whata puaroa* (place used as an altar), and then when the sacred *mara tautane* (ground in which is grown *kumara* for the gods) is being cultivated he bury the *manea* in that place, together with some of the seed *kumara*, then you will surely die.

Makutu was resorted to often for the purpose of avenging some insult, or to punish a thief or other evildoer. "A respectable *tohunga*, or priest," says Gudgeon, "of any standing in this profession would as a rule disdain to use his powers against a common man who might affront him, unless indeed the insult were very glaring, in which case discipline had to be maintained. "But," he adds, "there were *tohungas* and *tohungas:* all of them were not respectable." If a person offended another he could secure a sorcerer to bewitch his enemy to death on making a suitable payment. In a case of theft it was not always necessary to consult a *tohunga*. The person who was robbed might take a twig of a tree, and, going to a pool of water, invoke his special *atua* until the *wairua* of the thief appears. If the *wairua* appeared the thief would surely die. Or the person robbed might take to the *tohunga* the *hau* of the place from which the article had been taken. His *hau* would probably be a portion of earth on which the article had been laid. As the person approached the *tohunga*, the latter would see the ghost of the thief advancing by the side of the bearer of the *hau*. He would then call upon the spirit of the thief to confess. If he did so he was allowed to live. But should he deny the theft, then his *wairua* would be slain by the awful arts of the priest.

Riki Tatahunga, better known as "King Dick," died recently at Tauranga. Riki had been ailing for some time, and his illness was ascribed to witchcraft, brought on because he appeared as advocate against his own tribe in a Land Court case. As soon as the *tohunga* had diagnosed the case as being caused by *makutu* or sorcery no hopes were held out for his recovery, and death soon ensued.

By means of *makutu* a person could be made to offend against some law of *tapu* without his being aware of it, and in such case illness or death was sent by *atua* who had been insulted. And it has often happened that an innocent person has been sacrificed to the rage of the relatives of a sick man, under the belief that he had caused the disease by unlawful means. For instance, a few months ago a Maori named Hirawa Moananui became ill, and a relative named Tera te Teira accused Haora Tareranui of bewitching him so as to cause his death. It is alleged that he threatened that if Moananui died he would shoot Haora. Had Tareranui not been protected by the police he very likely would have lost his life.

This *makutu* business was the dangerous part of a *tohunga's* profession, for it was by no means an uncommon thing for a man who believed himself bewitched to load his gun and anticipate matters by shooting the wizard. "I have known one or two cases of this kind," says Gudgeon, "and one in which an old man, having threatened to bewitch his daughter-in-law because she refused to allow him to take charge of his grandson, was deliberately, and with the consent of the tribe, doomed to death and shot by his own son. *Makutu* is a two-edged sword." In the year 1844 a slave and his wife were killed at Hokianga for the supposed crime of witchcraft. "Even in these days," writes a colonist in 1861, "the lives of nearest relatives are sometimes sacrificed to the still strong belief in these Satanic rites, and for the supposed crime of witchcraft murder is still perpetrated." In modern days the gun is the favourite means of protection against sorcery. In olden times if a Maori was guilty of the crime of killing, or attempting to kill, by means of *makutu*, without just cause, he was usually punished through the agency of his *hau*—that is to say, his *hau* was taken and his body doomed to death in the usual manner by *makutu* or sympathetic magic.

The Maori magician is generally an aged man, but he does not cover himself with charms and amulets, bones of animals, beads and bells, and such ornaments and grotesque personal decorations so dear to the medicine-man of the Zulus and other primitive races. He whirls no terrifying bull-roarer, carries no bag of disease-dealing or disease-destroying charms or bundles of magic herbs. Nor can he travel underground, or fly enormous

distances with marvellous rapidity, as do the Australian sorcerers. To gain entrance to the profession he does not need to have some marked physical deformity or hideous countenance. The most powerful *tohunga* was often of high birth and held a high and influential position in the tribe. He believed implicitly in his powers, and was often an extremely shrewd man. His stock-in-trade consisted of a knowledge of very many *karakia;* an ability to interpret omens; a bodyguard of good genii or familiar spirits who at his call would attack and kill his enemies or their attendant familiar spirits (*atua*); and a large amount of common sense. He sometimes carried a staff, sometimes a *taiaroa*, a peculiar long ornamental staff used for purposes of enchantment.

Maori sorcery differs very considerably from that of the Australian blacks, especially in the absence of all those practices by which foreign substances are magically introduced into the victim's body to set up disease, and also in the total absence of any such custom as the magic extraction of the kidney-fat. Australian aboriginal sorcerers kill by "pointing the bone," or by transmitting to the body of their sorceries small fragments of magic rock crystal, or bone, or chips of wood, or other hard substance. These entering the vital organs cause pain, disease, and death. The Maori *tohunga* kills either by sending a demon or spirit to gnaw the vital organs, or he, by symbolic magic, extracts, or in some way destroys, the life-principle (*hau*), or the dream-ghost (*wairua*).

The potency of *makutu* depends far more on the repetition of special cryptic *karakia* (incantations, invocations, charms, &c.) than on the proper performance of any elaborate ceremonials. The great essential to nearly all the rites of sorcery among the Maoris was the correct rendering of the ancient and often very long incantations; the accompanying rites were generally simple, and often consisted in sprinklings with water, and the symbolic burial of the soul of the victim.

Forms of Sorcery

(a.) Charms and Curses.

According to Gudgeon, "there are many degrees of a Maori curse, and those being the cause of a person becoming bewitched, a few specimens will not be out of place. There are three principal degrees—viz., the *kanga*, the *apiti*, and the *tapatapa*. The *kanga* is the superlative curse, and has various forms, as "*Upoko kohua*," which means, "You skull to cook in," and "*Upoko taona*," "You cooked head." The *kanga* is an actual wish that the person cursed may be eaten—absolutely the most terrible and degrading end that any Maori could have. The *apiti* is a

literal comparison, in which the person's bones are likened to a fork, or the skull to a drinking-cup, as "*To upoko ko taku ipu wai*" (Your head is the calabash from which I drink); "*Ko taku tirou kai o whena*" (My food-fork is your bones). There is also a lower degree, *tapatapa*, which is by calling the name of any animal or thing after a person. To remove the bewitching effect of these curses elaborate ceremonies have to be performed by the priest, who repeats numerous incantations and counter-charms: these ceremonies continue in some cases for three days. They are fully discussed in another part of this paper.

(*b.*) *Rites and Ceremonies.*

The Maoris induced insanity by means of sorcery, sometimes in the spirit of revenge, as when a lover resorted to that form of black magic called *whaka-tihaha*, in order to drive mad and kill the woman who had repelled his amorous advances. The *rotu* is a potent spell to throw a person into a magic sleep, prior to a murderous attack perhaps, and commences thus: "*O mata e tiro mai, nana tu whakarehua, tu whakamoea, e moe!*" which may be translated thus:—

O eyes that behold,
Be thou closed in sleep,
Be thou fast in sleep, sleep.

Much more potent, however, than the *rotu* was the deadly *tipi-whaka-moe*, or sleep-causing stroke, which was the sudden letting fly a mystic power by the wizard, resulting in the sudden death of his victim. *Mata-rere-puku* is the name of a species of witchcraft so called because the charm was effected by the tip (*matamata*) of the tongue of the sorcerer secretly (*puku*) applied. *Umu pongipongi* (*umu* = oven, ceremony ?) was some form, ceremony, and *karakia* to bewitch. Its exact nature is not known.

The Rua-iti Rite (*rua*, a pit, a grave; *iti*, small).—When a priest wished to slay a person by symbolic magic a commonly used form was that known as *rua-iti*. The sorcerer secretly digs a small hole in the ground and places in it, or moulds at the bottom of the pit, a mound of earth in the form of the human body. Taking a cord in his hand, and standing over the hole, he allows one end of the cord to hang down in the hole. He then repeats potent incantations to cause the *wairua* (dream-ghost) of the doomed person to descend by way of the cord into the hole, where it is destroyed by means of another powerful *karakia* known as *whakaumu*. In some cases the cord seems to have been dispensed with, and the *wairua* is then seen to enter the hole in the form of a fly (*rango*), such fly being the *ahua* (semblance) or *aria* (form of incarnation) of the spirit of the victim. Or the *ahua* in other cases appeared over the pit as a small flame or light, a will-o'-the-wisp, which was promptly cursed, and its

owner thus secretly doomed to death. If the cord is used it is indispensable that the sorcerer should procure it from the home of the doomed person. The counter-ceremony for the *rua-iti* sorcery was thus described by a Maori to Elsdon Best: "Should I become aware that a *tohunga* is bewitching me so as to cause my body to waste away—and I should know at once if he were—I send some one to his place to bring me a piece of cord, of any kind. I take the cord and smear it with blood procured from an incision in the left side of my body. I then kindle a fire and burn the cord; also, I cook a single *kumara* or *taewa* at that fire. The cooked *kumara* I give to the *ruahine* (a childless woman employed in various sacred rites), who eats it. Friend, that man is dead! Another method of averting the evil is to place the *kumara* beneath the *paepae-poto* (door-sill) of my house and get the *ruahine* to step over it." It is not easy to explain the rationale of this counter-ceremony. Perhaps, however, the string is an *ohonga* (bait), and by cooking a *kumara* at the fire in which the *ohonga* was burned the *aria* of the victim is transferred to the *kumara*, the eating of which is symbolic of his destruction. The burning of an *ohonga* is sometimes considered sufficient to cause the death of the enemy.

Many ailments are supposed to be caused by magic, as insanity (*porangitanga*, *porewarewa*, *porangi*, *wairangi*, *haurangi*, *potete*, *apa*, *awhireinga*), leprosy (*ngerengere*, *mutumutu*, *tuawhenua*, *tuhawaiki*), wasting sickness, and many obscure complaints of the internal organs, both chronic and acute. Sorcerers were supposed to be able to bring about the death of their victim within a week, sometimes at the end of the third day after the commencement of their magic rites. Many deaths resulted doubtless from melancholia or fear.

We have seen that when a person's illness has been caused by magic the *tohunga* can identify the individual by whose evil sorceries the disease-demon was sent, either by means of the *hirihiri* or of the *paepae*. But if the patient be dead when the priest arrives, then he will find out who caused his death when the body is buried, either when the grave is being prepared or when the body is being placed in it, or sometimes afterwards. If the *tohunga* arrive before his patient dies he may be able to counteract the sorcery. If the case is a complicated one and his patient is of high rank, then the elaborate and prolonged rites and incantations about to be described must be carefully carried out to effect a cure. In minor cases a man might undertake his own cure, for most people had a knowledge of charms or simple *karakia* to ward off sorcery. But if he had opposed to him a very powerful *tohunga makutu* his own *karakia* would not have sufficient *mana* to overpower those of his

adversary, and he must either call to his aid a capable sorcerer or die.

When, then, a man believes he has been cursed or bewitched by a powerful magician he is taken by his *tohunga* to the sacred stream, and, making mounds of earth beside it, the priest sticks a twig of *tangeo* (*Tetranthera calicaris*) into the bank; then they immerse themselves in the water, the sorcerer repeating this incantation, while the gods are supposed to come and rest upon the mounds, and dance upon the twigs set up :—

Now are the mounds made,
On the side of the dark stream,
By the place of thy wanderings, and of thy curse.
Now stands the twig by the mound:
It is the twig of revenge,
To hurry onward my power,
Emblem of the gods and their power.
Now is the power of this incantation,
Of these sons and of these emblems.
The water is flowing to this place of sorcery:
It flows on to this sacred spot.
Thou son of evil words and this curse,
Thou who didst defy the priests with a curse,
By these emblems, fall thou, die thou
With suddenness be thy death:
Die quickly for thy curse and evil word.

This done in the water, they return now to the settlement and make a space clear of grass or weeds as an arena on which the gods (*atua*) may alight. While clearing the ground the *tahinga* invocation is repeated :—

Sweep, sweep an open space
For the god of power
On which to sow death, to revenge these sons.
Tu* the powerful, and Rongo,*
Itupaoa†, and Ihungaru†, come,
Sow death for this word and curse.
Darkness, come from the world below,
From the gods below,
From the worm below, and smite these sons.

Within the open space the sorcerer digs a hole (*rua haeroa*) about 2 ft. long, which is intended for a grave for the spirits (*wairua*) of those who cursed, and while digging it this *karakia* is repeated :—

Now is the pit dug to the depth of Nuku,
To the limbs of the earth, to the depth of Papa,
To the uttermost darkness below, to the long night,
To the utmost darkness, to the power of these priests,
To the darkness of the gods of these sons and emblems.

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* National gods.

† Tribal gods formerly kept at Mokoia (Rotorua). They were brought from Hawaiki at the time of the Maori advent to New Zealand.

This done, and the grave finished, they put a twig of the sacred *karamu* (*Coprosma robusta*) on each side, and seat themselves on its brink, and take a shell of a fresh-water mussel with which to scrape into the pit the souls of those who bewitched the patient, which have already been brought to the pit's edge. While doing this, again the priest begins :—

Let the revenge of Tu consume these sons,
Their priests, their gods, their power and incantations.
May the power of their sorcerers be confounded;
Let their wizard god be made dumb.

A narrow ridge is then made along the side of the grave, upon which the *tohunga* places stones named after those who used the curse, one for each, and says :—

To sweep in, to cover up, kill and bury them ;
For thy power in war, thy strength and anger, &c.
Thou art struck down to the depths of Nuku,
Even to the root of the world thou art sent,
As food for the hosts there ; thy powerless incantations also.
Thy ancestors and their power is gone with thee ;
They are now weak and cannot kill.
We sweep them and thee into this pit,
And hide you altogether with this shell,
The shell of these sons and emblems.

This is repeated over every stone, and each time he comes to the name "Nuku" he strikes into the pit the stone to which it is addressed. The twigs are now thrown likewise into the grave ; then he fills the hole, and pats down the mound with his hands. They have thus, by symbolic magic, consigned the opposing sorcerers to the grave. The next day they come there again, and, weaving a basket which is of very small size, and called the demon's basket (*paro taniwha*), the priest again repeats :—

Weave my basket for my sons to sleep in :
My basket is for my dead sons and enemies.
To whom does the basket belong ?
To the gods and priests and ancestors,
To the sacred powers and female ancestors,
To the gods of theft. Fill up, fill up my basket !
It is to put you, your priests, gods, and incantations,
Your power in incantations.
To whom does the basket belong ?
To the female ancestors and you all,
Even to the stay of all power, the gods of theft

The bodies of their enemies were buried in the twigs, the stones representing their hearts, cold and dead as they. Now their spirits (*wairua*) are imprisoned in the basket, and, being hung up on a stick above the grave, and squeezed by the hands of the priest, are thus offered to the gods. By thus squeezing the ghosts of the hostile sorcerers, their bodies, being in sympathy with the spirit, were contorted with internal pains, and death soon ensued.

On the third day, at a little distance from this pit, they build a hut, and make a mat and lay it on the pit. They then make an effigy of *raupo*, putting within it a stone to represent the heart, and laying it on the mat. This is called Whiro (the god of thieves). They then address the figure :—

Sleep, O son, sleep !
Sleep thou on the grave of the sinful men.
They are gone to the long night,
The night of manifold darkness ;
They are gone to the end,
To the thousands below.*

The mat and effigy are lastly taken up and destroyed in the hut, and the priest, standing at a little distance, asks " Are you asleep, Whiro ? Arise, arise ! Go thou to the gods in the depths of Nuku, to the worm, to the depths of the dark world, to the evil, to the gods of power, to the end of evil." This concluding ceremony is called *whakaoho*, and the curse is finally removed from them and transferred to him or them who uttered it.

Finally the *tapu* has to be removed by the eating of specially prepared fern-root which has been applied to the head and shoulders of the patient. Both are then polluted (*noa*) and unfit for further rites of sorcery. This is done to protect others from bewitchment by contact with them, and to prevent the secrets of the craft being divulged. Another *karakia* accompanies the resumption of their garments ; for had they touched cooked food without these precautions, the sorceries of the priest would return upon his own head. So end the ceremonies, which must be concluded before day dawns or closes upon them.

For three days afterwards they must both eat only the *pohue* (wild convolvulus) root to insure the complete success of their sorceries. Nor is this success in the least doubtful if they be left to their uninterrupted operation ; yet if the offending man relent, and would avert the death thus menaced, it is still in the power of the priest to undo his work, and to effect a cure on the bewitched man by repeating this *karakia* over him :—

As the sounds of music from the *koauau*,
Such shall be thy returning soul
To this world of health,
To this world of light.

So saying, he spits on the sick man's forehead, and, laying his hand upon him, says :—

Evil man, great sinner,
Thou art of Maui.

These words complete the cure.

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* This account is from John White's Lectures.

If a curse were uttered against a sorcerer, he would not speak at the time, but silently repeat the following incantation :—

Tu, baptise the night;
Tu, baptise the day.
Go thou beneath, I go above
Send thy power below
To the night below, to the worm below,
To the evil one below. Go to death,
And thy spirit for ever to darkness.

Then, returning home, he fasts three days, to insure that the offender shall have eaten food, which will enhance the effect of his incantation. When he is certain of this he has food cooked for himself, and, taking part of it, he wraps it in a *nikau*-palm leaf, with some hairs from his own forehead, and, taking it to a running stream, he throws it in, saying :—

My fire is burning
To the big sea, to the long sea,
To the boisterous sea.

Then he returns, and while eating, lest he who cursed him should have bewitched his food, he repeats silently :—

Stand erect before the world of spirits
That the soul of food may be eaten,
And the essence of food—the food of the gods.

This completes the charm against the offender—he is now doomed to certain death; and, that the cause of it may be known, the ghost of the sorcerer will appear bodily at the funeral. The relatives then, seeing and recognising it, will go to a running stream, and, sitting on its brink, repeat this incantation :—

Our protector will destroy his power,
He will protect from death.
Go thou evil one to the heaven above,
Go thou to the earth beneath.

This charm precludes any future sorcery being exercised against the remainder of the family. Occasionally, however, instead of all these ceremonies, the sorcerer, when cursed, will lay his left hand on the right side of his breast, and with the right hand catch the curse, saying aloud, "*Au taku upoko!*" (Oh, my head!) for on the head dwell the principal gods, and they are thus called to punish the offender with death.

Such is the description of the ceremonies of black and white magic, of symbolic and sympathetic magic, of the Maoris as recorded by John White.* In addition to these complicated *karakia* and mystic ceremonies, there were in every-day use simpler rites, charms, spells, and magic formulæ used by the common people, and on less serious occasions by the sorcerers. If, for instance, the *tohunga* has satisfied himself, after looking

* "Maori Customs and Superstitions," 1861.

at the patient, that his sickness is not attributable to the influence of *makutu* (witchcraft), he merely repeats this incantation, with certain contortions of his body, clawing the air with his hands over the patient, sometimes standing, sometimes sitting; but no certain rules can be given, for the ceremonies in this case are quite arbitrary on the part of the priest. Some of them never come near the patient, merely repeating the incantation while they are standing on the top of their own house, which is as follows :—

Breathe thou, breath thou, breathe, O Rangi!
And thou Tu, give thy living spirit
To create life, that the body and soul may live in the world
Beat with life thou heart.
The tree falleth, the tree of Atutahi.*
Here the blow was given, the wind blew there,
There is the tree of enchantment.

Whakahokitu is a form of *makutu* used to counteract the sorceries of hostile wizards. The following is a specimen of the *karakia* used on such occasions :—

Great curse, long curse,
Great curse, binding curse,
Binding your sacredness
To the tide of destruction.
Come hither, sacred spell,
To be looked on by me;
Cause the curser to lie low
In gloomy night of ill-omen.
Great wind, lasting wind,
Changing wind of Rangi above,
He falls; he perishes.
Cause to waste away the cursed *tohunga*
Let him bite the oven-stones,
Be food for me,
The *tapu* and the *mana*
Of your *atua*,
Of your *karakia*,
Of your *tohunga*.

Matapuru were a class of protective *karakia* used to ward off witchcraft. The *kai-ure* charm belonged to this class. If a man came to know that he had been bewitched, or that some wicked sorcerer was trying by *makutu* to take his *hau* (vivifying spirit), he would immediately procure some strips of *harakeke*, or flax, and tie them carefully around his body and limbs—perhaps to prevent the escape of the *hau* or the *wairua*. He would then recite a *matapuru*, or guardian charm, to render harmless the spells of his enemy.

* The star Canopus.

The Grand Healing Rites.

(1.) Ripa *or* Parepare (*the Defensive Charm*).

When a person, in former times, believed himself falling ill he would consult the *tohunga* in order to get him to avert the trouble. The priest would take him to the waterside—a pond, pool, or stream near the village, at which many rites were performed, and which was avoided by the people at other times, it being sacred (*tapu*). These rites were always performed early in the morning, or after sundown in the evening. The priest would divest himself of his clothing, save a girdle round his waist, and the patient had to disrobe and appear in a similar manner. Bearing a small branch of the *karamuramu* shrub in his hand, the priest would enter the water, and, dipping the leafy end of his wand in the water, sprinkle the water therefrom over his patient, repeating a *karakia* to avert the evil influence at work on him, or to weaken or destroy the power of the attacking *atua*. Such a charm is a *ripa*, *parepare*, or *momono*, which terms mean " to avert, to ward off, to overpower." The following is a specimen of such a *karakia* :—

Whakataha ra koe
E te anewa o te rangi
E tu nei
He tupua, he tawhito to tohu
To makutu e kite mai nei koe
E homai nei koe kei taku ure
Na te tapu ihi, na te tapu mana
Takoto ki raro ki to kauwhau ariki.

In those cases where diseases were supposed to have been caused by *hara* (infringement of the *tapu*) the aim of the *tohunga* or seer was to divine what sin (*hara*) had been committed by his patient, after that his course of action was clear to him. For it would often be that the patient himself would be ignorant of the cause of his illness—that is to say, ignorant of having disregarded any of the numerous laws of the Maori system of *tapu*. In order to ascertain, or diagnose, the cause of the illness of the patient, the *tohunga* would tell him to accompany him to the *wai tapu*, or sacred pool, described above. Thither they would proceed after sunset. Should the sick person be feeble, one or two persons would be allowed to assist him to the waterside. All the rest of the inhabitants of the village would remain carefully within the huts, lest their *wairua* or spirits wander forth to the waterside and there be destroyed by the magic spells of the priest as he performed the rites over the sick person. And if a person's *wairua* was slain, naturally the body, its physical basis, must also soon perish.

(2.) Hirihiri (*the Diagnostic or Prognostic Rite*).

Having the invalid stripped at the waterside, the *tohunga*, clad in scant girdle of green branchlets, enters the water, and with his wand sprinkles water over the sick man's body, and repeats an invocation termed a *hirihiri*, for the purpose of finding out the cause of his patient's illness. A Tuhoe seer would *whakahirihiri* thus: —

Kotahi koe ki konei
Kotahi ki a Te Reretautau
Kotahi koe ki konei
Kotahi ki nga ariki.
Kotahi koe ki konei
Kotahi ki nga matamua.
Kotahi koe ki konei
Kotahi ki nga wananga
Kotahi koe ki konei
Kotahi ki nga tapu
Kotahi koe ki konei
Kotahi ki a Te Haraki.

This is a special form of *hirihiri*. When the seer repeated the name of Te Haraki, a noted wizard of the Ngatiawa, if the patient gasped, his limbs stiffened, his eyes turned, his last breath was expelled like unto a long sigh, and he died, then it was known that the wizard Te Haraki had caused his death. Had he expired when the name of the sorcerer Te Rere-tautau was mentioned, then his death would have been attributed to that magician. Had he died when the word *tapu* or *matamua*, &c., was being repeated, then it would be clear that some transgression of *tapu* had caused his death. For instance, had he inadvertently eaten food prepared for a *matamua*, or first-born member of a high family—a most sacred individual—that would have been the cause of his death, and he would have expired when that word was pronounced.

The Tuhoe tribe often used the following *hirihiri* :—

Kotahi koe ki reira
Kotahi ki te manuka i Whakatane, &c.,

the *manuka* at Whakatane being the great *mauri*, or talisman of life and health, of the Matatua tribes. When Kahungunu wandered away to distant lands and knew that Tamatakutai was trying to bewitch him, he saved himself by repeating—

Kotahi au ki konei
Kotahi ki te manuka i Whakatane.

Another example of the *hirihiri* runs thus :—

Kotahi koe ki te whare
Kotahi koe ki te kakahu
Kotahi koe ki te moenga
Kotahi koe ki nga whenua, &c.

In these lines occur the words " house," " garment," " bed," " lands." Should the patient gasp when any of these lines were repeated the cause of the sickness would be known: if at the word " bed," then he has trespassed on the sleeping-place of some *tapu* person; if at the word " house," then a sacred house, or the site thereof, has been desecrated by him.

When the cause of the illness has been the offence termed *kai hau*, or wrongful giving away of another's property, then the patient would expire when these words of the *hirihiri* were repeated :—

Kotahi koe ki te taonga o (mea)
I whiua ketia e koe te utu.

The expressions " Kotahi koe ki konei, kotahi ki Whakatane," &c., in the above *karakia* really mean, " You are lying here stricken by illness, while the *mauri ora* which can save you is at Whakatane." It will thus be seen that the *hirihiri* rite has two bearings. In the first place it is a species of divination employed to discover the cause of illness, and in the second place it implies a protection of man, his life, vitality, vigour, &c., against influences of a supernatural nature, such as witch-craft, the consequences of disregarding *tapu*, &c.

When the priest has performed his *hirihiri* rite over the sick person, and has found the cause of illness is witchcraft, he will say, " You have been meddled with. So-and-so has bewitched you. I see him [*i.e.*, his *wairua* or spirit] standing by your side. What shall be done with him ? " Should the victim of his machinations reply " *Patua atu* " (Destroy him), then the *tohunga* will, by his counter-magic, cause the attaking sorcerer's death. Ere long, the news will arrive that he is dead. The following is an example of a *karakia* used for this purpose :—

Haere i te po uriuri
Haere i te po tangotango
Haere i te po te hoki mai
Haere i te po te oti atu
Muimui te ngaro
Totoro te iro
Mau ka oti atu
Oti atu ki te po.

Another mode of treatment in cases of sickness diagnosed as being due to witchcraft is for the *tohunga* to take his patient to the sacred pool, and, after sprinkling him with the " holy water," to repeat this invocation :—*

Rise all ye powers of this earth,
And let me see the gods.
Now I am roaming over the earth,
May the gods be prevented

* " Maori Customs and Superstitions," John White, 1861.

From cutting and maiming this man.
O thou god of the wizard,
When thou descendest to the world below,
To thy many, to thy thousands,
And they ask who required thee there,
Say Whiro the thief; come back then
And we shall find thee, we shall see thee.
When thou goest inland,
Or to the ocean, or above,
And the thousands there ask thee,
Tell them the same.
Go thou even at day-dawn,
Where the night's last is,
Hide thyself in it, and go.
Go thou, but the skull of the wizard shall be mine
To cut and to tear it,
To destroy its power and its sacredness
Cut off the head of the god.

Then patient and priest return to the village. The invalid being very *tapu*, he is *ihowaka*, and must not eat ordinary food for three days: at the end of that time the cure is supposed to be complete.

That class of priests termed *tohunga matatuhi* or *matakite* (*mata*, a medium of communication with a spirit) usually performed the *hirihiri* rite, inasmuch as they were supposed to be masters of divination and second sight. It is, of course, the god (*atua*) or familiar spirit of the *tohunga* who enables him to ascertain the person or object which is the cause of illness. Sometimes the priest would perform the *hirihiri* at his sacred place, where he kept the symbol of his *atua*, and addressed his *karakia* to it. And the god would explain the cause of the illness through his human medium (*waka*, *kauwaka*, or *kaupapa*) —that is, through the *tohunga*. When the priest had performed these rites over a sick person, it was customary to present to him the cloak or garment which had been used to cover the patient when being taken to the sacred pool.

Many of the sacred rites of the Maori were performed in or on the banks of some sacred pool or stream. A pool or pond was preferred, inasmuch as the permanent *tapu* placed over it did not interfere with the domestic requirements of the tribe. The water of a *tapu* stream would not be available for household purposes. The sacred pool was called *wai tapu*, or *wai whakaika*, and people were not allowed to approach near it unless conducted thither by a *tohunga*, in order to go through some religious rite or ceremony. The reason why a sick person is taken to the *wai tapu* is thus explained by the Ngatiawa Maoris: "He is taken to his ancestress Wainui, who makes all such things clear in regard to the troubles which afflict the Maori people. The cause of his sickness will there be disclosed, whether it be

witchcraft, or desecration of a *tapu* or sacred fire, house, bed, or burial-place, &c. For Wainui was of the offspring of Rangi and Papa, the primeval progenitors of the universe and of man. And Wainui is the Mother of Waters, the origin and personification of waters, of the ocean, of lakes, of rivers and streams, even as Para-whenua-mea is the personification of floods."

The Prognostic Rite.

The morning after the patient has been taken to the sacred pool the *tohunga* performs further rites over him in order to divine whether the patient will recover from his sickness or whether death will ensue. For this purpose a sacred *umu* or steam-oven is prepared by the priest, and among the food placed therein the priest places a certain portion over which he has recited a charm or spell which comes under the generic term of *hoa*. When he uncovers the oven, should that piece of food be found thoroughly cooked it is a sign that the patient will recover, and that if he has been bewitched the offending wizard will die. On the other hand, if the food is found to be uncooked, that is a sign that the patient will die. The food cooked in the oven is eaten by the sacred first-born female of a family of rank, who is employed as a *ruahine* (priestess) to remove the *tapu*, in this and many other rites. The afflicted person is often told to procure some special food for the above oven.

(3.) Takutaku (*the Exorcising Rite*).

The illness having been diagnosed by the *tohunga* as being due (*a*) to demoniac possession, (*b*) to sorcery, or (*c*) to an infringement of the *tapu*, he proceeds to repeat the *takutaku karakia* suited to the particular disease. This form of incantation is used to exorcise the evil spirit which is the cause of the trouble.

The *takutaku*, like the *hirihiri*, was often performed at the waterside, the person being sprinkled from the sacred staff of the medicine-man, as before described. The general meaning of a *takutaku* was given to Mr. Elsdon Best—to whom I am indebted for most of the information on the rites now under consideration—as follows: The *tohunga* in his *karakia* endeavours to coax the *atua* out of the body of his victim by saying, "Here is your path by which to leave. Cease afflicting this person. Return to your origin, to your caretaker. You are an important person. Will you not succour this person?" The flattery here is doubtless diplomatic, but a request made to the malicious devil to succour his victim could hardly be followed by the desired effect. If the *atua* refuses to leave his victim, it is the duty of the *tohunga* to find out the path by

which the spirit came from the lower regions to the upper world, in order that he may be made to return by the same way he came. He proceeds thus: Going to the river or seaside, he dips his head beneath the surface of the water, while the relatives most interested in the case remain seated on the shore to witness his success at divination. Perhaps he does not succeed the first time, so he dips his head into the water a second time. If not then successful, the third time is probably enough, and, raising his head, he assures the anxious spectators that he has found the path, and that the *atua* came from below upwards through a flax-bush, or the stem of *toetoe* (*Arundo conspicua*), as the case may be; for it is a general belief that the paths selected in preference by spirits, when on such journeys, are the inner shoots of a flax-plant (*Phormium tenax*) or of the *toetoe* grass, the stalk of the common fern (*rarauhe*) or of the plant termed *tutumako*. It still remains, however, to discover the identical stem selected by the demon. So the *tohunga* sets off to the neighbouring stream or swamp to search for it. He takes hold of one of the young leaves, and, grasping it firmly, repeats :—

He kimihanga
He rangahautanga
Ka kimi ki hea ?
Ka kimi ki uta
Ka kimi ki te pu
Ka kimi ki te more
Ka kimi ki te po
Ka kimi ki te atua
Kia mana koe.

He then tugs at the leaf, pulling it out from the sheath. Should the pulling-out cause the parting leaf to make a screeching sound (*e rara haere ake te waha o te rito o te harakeke*), he knows he has discovered the right one. Armed with the flax-stalk, he goes to the patient's bedside, and places one end on the body of the sick person, or hangs it over his head. This is an *ara atua*, or path by which the *atua* or demon afflicting the person is to pass out of the sick person's body, in response to the *takutaku* exorcising charm. The spirit relents, and, seeing a path close at hand for his return to the lower regions, he departs, and straightway the sick man is convalescent.

If, when the *takutaku* is being performed, the *atua* leaves the patient at once when called upon by the priest to depart, then it is known that it was the patient's own god which was afflicting him. If the *atua* be a stubborn one and difficult to expel, then it is a strange demon, probably sent by a hostile sorcerer, or by one of the tribal or family gods as a punishment for breaking the *tapu* laws.

The following is a specimen of the *takutaku karakia* :—

4—Trans.

To ara
Haere i tua, haere i waho
Haere i te maramatanga
Haere i nga kapua o te rang
Haere ma hihi ora
Ki te whai ao
Ki te ao marama
Ko rou ora.
Haere i a moana nui
Haere i a moana roa
Haere i a moana te takiritia
Ki te whai ao
Ki te ao marama
Ko rou ora.

(4.) *The* Oho rangi *Rite.*

The *oho rangi* ceremony caused the heavens to thunder, and was designed to give *mana* (power) to the preceding rites and incantations. It was believed that if the thunder rolled at the call of the *tohunga*, then the sick person would certainly recover. But if it did not, that was a bad omen.

The *oho rangi* rite was performed when the sun was declining. "For," said an old Maori, "when man was in the grasp of death, then tears for his plight were demanded from the heavens, and the wise men of old called on the thunders to sound."

The Tuaimu *Rite—to render the Disease* (Atua) *powerless.*

This rite consists in the performance of certain ceremonies and the repetition of certain *karakia* known as *tuaimu* or *tuaumu* (*tua*, to subdue), the object being to render the hostile sorcerer, his *atua* and his *karakia*, powerless.

For this purpose the priest would obtain a piece of one of the plants which come under the generic term *puha* or *puwha*, to which he added a piece of dead ember from the fire. Taking the herb and ember, he would pass them round the left thigh of the invalid, from left to right. He would then wave his hand containing those two articles towards the heavens, the objects themselves being afterwards taken to the *tuahu* or sacred place of the village, where, it is said, another invocation was repeated in order to restore health to the invalid. It appears to have been believed that the *ahua*, or semblance, or personality, of the disease became, as it were, absorbed into the articles passed round the thigh, and that in the waving of them towards the heavens the said personality flew off into space. This singular custom was performed on the left side because that is the *taha ruahine*, the female side and the *noa* (common or *tapu*-less) side of man. The left side of man has great *mana* although it be not *tapu*.

While performing the above the priest repeated the following :—

Ka oho te po
Ka rongo te po
Ka rongo te ao
Ka oho ki tua
Ka oho ki waho
Ka oho ki nga koromatua
Ka tupu, ka rea
Ka puta ki te whai ao
Ki te ao marama.

After which he recited the *tuaimu*, as follows :—

Te imu kai te ruhi
Te imu kai te rongo
Ka rongo ki uta
Ka rongo ki tai
Ka rongo ki te po
Ka rongo ki te ao
Tuku tonu, heke tonu
Te ika ki te po
He ika ka ripiripia
He ika ka toetoea
He ika ka haparangitia.

This rite was sometimes performed without the aid of the *tohunga*. For instance, if a person when sleeping be warned by his *wairua* (dream-ghost) that a *tohunga makutu* is trying to bewitch him, then as soon as he awakes he must go and stand before the altar of the tribal gods (*atua*, or ancestral ghosts), and, standing facing the direction in which the hostile wizard lives, he stretches forth his hand and repeats :—

Avert thee, then,
O thou paralysing power of heaven !
Supernatural power of old is thy witchcraft
That thou appliest to my organs,
By the dread *tapu*, by the all-powerful *tapu*.
Fall thou in front, prostrate below,
To thy *kauwhau-ariki*.

After this he must recite an incantation (*tuaimu*) to weaken the power of the enemy :—

The rite to effect exhaustion,
The rite to effect the killing
With the paralysing power
Thy hand be wounded, thy hand be rotten,
Press down earth, press down sky,
Headlong falls thy prominence.
Broken neck,
Away, descend the victim to Hades,
A victim that is slashed, is torn in shreds,
A victim that is uprisen.
Gather the flies, spread the maggots,
Begone for ever to Hades,
Begone to the Hades of blackness.

(5.) Whakanoa, *or* Whakahorohoro (*the Rite of Purification*).

When a priest-physician had been attending a sick person and the latter recovered, there was yet another rite to be performed. This was done either in some sacred place near the village, or at the sacred pool (*wai tapu* or *wai karakia*) of the village. Here the *whakanoa* rite was performed, and the priest concluded the ceremonies by causing the thunders of heaven to sound. This last is termed the *oho rangi*.

A person or place was *whakanoa* by means of *karakia* and cooked food. A *kumara* or piece of fern-root was roasted by the priest, which was eaten by the *tapu* person, or placed to his lips, or simply his body touched with it. A woman was often employed to lift the *tapu*, because women are *noa* from and before birth. In some cases the *horohoro* (casting-off) rite consisted in the *tohunga* offering a small quantity of sacred food to his *atua*, some of which he himself ate, and the remainder was consigned to the earth. After the priest had sprinkled the place with water the ceremony terminated.

VARIOUS RITES BY MEANS OF WHICH DISEASES WERE WARDED OFF OR CURED.

The Ngau Paepae *Rite.**

The singular performance known by the above name is one of the most extraordinary customs of a strange people—extraordinary even for a Maori. It consists of causing a sick person to bite (*ngau*) the beam of a latrine, with which native villages were provided in former times. By "sick person" is meant any one suffering from the effects of *hara* (transgression of the laws of *tapu*) or of witchcraft—*i.e.*, any person afflicted by the gods; and the vast majority of ills, pains, and diseases were so caused, according to Maori ideas. The one idea which seems to pervade this ancient rite seems to be that the *paepae hamuti*, or latrine, which is very *tapu* and possesses great *mana* (power, prestige) holds the power of being able to prevent or avert the effect of the anger of the gods, and the shafts of magic, which latter, although directed by man, are really carried out by the gods.

These rites performed at the latrine are described as a *whiti i te mate* (averting of evil or death or sickness), or as a *parepare*, which means the same thing, or as a *ripa*, which signifies "to deprive the gods of power, to put bounds to their power for evil." But the general term for the rite is *ngau paepae*. An old man said to me, "The *paepae* is the *tangata matua*,† it is the *hau ora* of man. It is the destroyer of man; it is the saviour of man."

* This description is from the Tuhoe Tribe alone.—E. B.

† A singular expression, which applies to a very ancient cult, perhaps of phallic origin.—E. B.

Should a person be going on a journey, he will first be conducted to the latrine and caused to bite the beam thereof: that will avert the magic arts of those he is going amongst. Persons going through this rite always stand in front of the bar, for that is life. The other side, the rear of the bar, is death, and is termed *kouka*. It is the Po; it is the *rua iti;* it is the realm of Hine-nui-te-Po. When performing rites of magic at the *paepae* whereby to slay man, the performer stands at the front of the bar, for that is the world of life. Should the *wairua* (spirit) of his enemy cross to the *kouka*, it will assuredly be destroyed.

But that sick person has yet to be cured. In the evening, when the sun has set, the priest conducts his patient to the *paepae*. They place themselves before the bar, the priest saying, "*E ngau to waha ki te paepae*"—*i.e.*, commanding the person to bite the bar, which he does. The priest repeats,—

Ka kai koe ki tua
Ka kai koe te paepae
E takoto nei.
Koia nga tapu
Koia nga popoa
Koia nga whare
Koia nga urunga
Koia nga tapu nei
He atua kahu koe
Haere i tua
Haere i waho
Haere i te rangi nui e tu nei
Mahihi ora
Ki te whai ao
Ki te ao marama
Ko rou ora.

They then return home, and the rite is over. It is said that the demon who has been afflicting the person would sometimes be seen to leave his body and fly off into space, and in the gathering shades of night a shower of bright objects would be seen flying off, these being the offspring of the expelled demon.

When a person had been guilty of trespassing on a sacred place, such as already explained, the *ngau paepae* rite will take the *tapu* off him and save him from the effects of his act—*i.e.*, save him from being afflicted by the gods. Here is the sort of *karakia* used on such occasions:—

Ngaua i te pae
Ngaua i te wehi
Ngaua i te upoko o te atua
Ngaua i te rangi e tu nei
Ngaua i a papa e takoto nei
Whakapa koe ki te ruahine
Kia whakaorangia koe
E tahito nuku, e tahito rangi
E tahito pamamao
Ki Tawhiti i Hawaiki.

In time of war, any interference with *tapu* objects, persons, or places has the effect of causing the person to be afflicted by Tu-mata-rehurehu—*i.e.*, he will become nervous, apprehensive, listless, and also lose his power of second sight, hence he will be of no use in the fray. These afflictions may, however, be cured by the above rite, or by the *hirihiri*.

The following is another *karakia ngau paepae* :—

E tu haupa a nuku
E tu haupa a rangi
Ka haupa ki runga
Ka haupa ki raro
Ka haupa ki te paepae roa i Hawaiki.

Kai ure (*Tuhoe*).

Any one suffering from any of the numerous ills caused by witchcraft might be cured by the process or charm known as *kai ure*. Or it may be utilised in order to ward off the shafts of magic which some person is believed to be directing against you. In repeating this spell or charm, the reciter must clasp his *membrum virile* in his left hand. The following is a specimen of the incantation used (possibly not complete).

Ka rere te ringa maui ki te hopu i te tawhito, ka titoiria, ka karakia atu :—

Kai ure nga atua
Kai ure nga tapu
Kai ure ou makutu.

Another *kai ure* spell is that beginning—

Whakataha ra koe
E te anewa o te rangi e tu nei
He tawhito to makutu
E homai nei kei taku ure, &c.,

which averts or wards off the magic arts, and after which is recited the *tuaimu* spell, in order to destroy the wizard—

Kei te imu te ruhi
Kei te imu te mate, &c.

The Whakanoho manawa *Rite.*

The rite or invocation known by the above name was for the purpose of causing the breath of life to be retained by a dying person, and it is said that it was used to restore to life those who had died. Information regarding the actions of the priest are lacking, but below are given specimens of the invocation repeated :—

Ko to manawa, ko taku manawa
Heuea mai
Tutakina mai to manawa
Hoki mai ki roto nei
He urunga, he tapu
Kei te whiua, kei te taia

Mata taitaia te ihi nei
Mata taitaia te atua e patu nei
Haere i tua, haere i waho
Haere i te pu, haere i te more
Ka whiwhia, ka rawea
Ka puta ki te whai ao,
Ki te ao marama
Ko rou ora.

He karakia whakanoho i te manawa o te tupapaku (a charm to cause the breath of life to be retained by the sick):—

Ko to manawa
Ko taku manawa
Ka turuturua, ka poupoua
Ki tawhito o te rangi— e
Ko wai te atua e patu nei ?
Ko moana nui, ko moana roa
Ko moana te takiritia
Ki te whai ao
Ki te ao marama
Ka uru te ora, ka uru ki roto
Ka uru te mate, ka uru ki waho
Uru, toro hei.

The following example is a good one. A reference to the *whare o aitua*, elsewhere mentioned, may be observed therein :—

Kai hea ?
Kai hea te pu o te mate ?
Kai runga, kai raro
Kai te hikahika nui no Hine-nui-te-po
Wetekina i runga, wetekina i raro
Wetekina i te ate
Wetekina i te manawa
No hea te atua ?
No runga, no raro te atua
He tipua koe, he tawhito au
Wetea,
Wetea mai te whiwhi
Wetea mai te hara
Wetea kia matara, kia mawheto
Tawhito te rangi te taea
Tiu hara nui, hara roa
Kati te riri
Kati te patu e te atua
Ka pikitia e koe te tuahu nei
Ka kakea e koe te ihi tapu
Pikipiki, kakekake
Kia kite koe i te hua mokimoki
Tu te rupe, tu te kawa
Ko te kawa i numinumia ai
Ki te pa tuatahi, ki te pa tuarua
Ka haramai, ka whakakiki ahu mai
Ahu mai ki te ao marama
Mo te ao ano koe
Kai hea to ara e piki ai koe ?
Kai te rangi tuatahi, kai te rangi tuarua
Kai te rangi tuatoru, kai te rangi tuawha

Kai te rangi tuarima, kai te rangi tuaono
Kai te rangi tuawhitu
Tukua atu tama kia puta ki te ao
He ohorere te tokomauri
Tihe mauri ora ki te ao marama.

Another custom in former times was to utilise a piece of *aute* bark as a *waka atua*, an abiding-place for an ancestral spirit. This fetish would be brought and placed upon a sick person, and an invocation, commencing as follows, repeated, in order to exorcise the malignant *atua* :—

Koia nga haku
Koia ki te rangi
Koia ki te kapua
Kia tu mai taku kai roro
Ko mangungu, ko manono, &c.

Treatment of Wounds.

Both herbs and priestly incantations or prayers to the gods were resorted to in cases of serious wounds. If in war a warrior is compelled to strike down a friend or relative whom he does not desire shall die, he rubs some spittle on the body of the fallen one, at the same time repeating this charm :—

Mau ka hoki mai
Hoki mai ki te ao nei (Return to life).

For, being *tapu*, the saliva of the warrior is also *tapu* and possessed of healing and destructive power. If an important personage is seriously wounded he is led by the medicine-man to the *tuahu*, or altar where offerings are made to the gods, and certain *karakia* muttered to propitiate the gods, while the *atua* are fed with blood, and blood-clots from the wound are lifted up on a staff before the altar of the god Mua.* Then is repeated this healing incantation :—†

Provoking irascible sinew, strong to kill,
Hither is come the one they sought to murder.
Verily, thy own skilful doctors are here—
Thou and I together, indeed, as one.
Thy wound is sacred (*tapu*).
The celebrated first-born priestess
Shall cause the lips of the wounds
To incline inwardly toward each other;
By the evening, lo! thy wound shall become as nothing.
The stone axe which caused it
Was verily as the strong tide rushing on
To the shores and tearing up the bed of shell-fish,
Striving, provoking sinew, eager after food for baking:
The wounding indeed of the man

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* "*Mua*" is not the name of a god, but the antithesis of *muri*, a *tapu*-less place.—E. B.

† "The Ancient History of the Maori," T. White, vol. iii., p. 17.

Who courageously enraged the god.
Thy internal parts are all open to view,
Verily, just as the stirring up of the big fire
Burning in the *ma ae* (courtyard) of a *pa* (fort).
But, lo ! thou and I together are as one.

The Moriori invoked the god Maru to descend upon the crown of the head (the most sacred part of the body) of the injured person, and apply his healing power to the wound or injured limb. Then was repeated this ancient *karakia*,* which was originally used at the raising of Rakei from the dead :—

Come from the crown of the head ;
Be thou closed,
Be thou at ease, &c.
Let the bones close,
Let the clotted blood close.
Close earth,
Close heaven,
Close it with the closing of Maru ;
Close it with the closing of earth.

Maru was the Moriori god who healed wounds, severe cuts, and broken bones. His image was of wood bound round with a plaited rope made of *pingao* (*Desmoschœmus spiralis*).

If a Tuhoe native cut himself, say with a stone adze while working, he would first apply the implement with which he cut himself to the wound, and then repeat a charm such as the following, in order to stop the flow of blood and cause the wound to heal :—

Te whai one tuatua, one taitaia
Te haehaea, ko te piere
Te ngawha, tee katikati
Torokina, toro wheua
Toro katikati te uaua
E mahu, e mahu—e !
Werowerohia atu nei taku tao
Werowerohia i Utupaoa
E te toto pouri, nau mai ki waho
E te toto potango, nau mai ki waho
Kinikini, panapana
Ko mata te hakuwai
Ki wai ora, ki wai te mumuhu
Te ara maomao, te tini kai mata
Ki te ara ki Otuimukia
Ka puta kai waho kai te mokopu roa
E mahu—e !
E mahu—e !

Another Tuhoe *whai* charm for healing wounds runs thus :—

Te whai one tuatua, one taitaia
Ko te piere, ko te ngawha
Ko te kapi ka — pi
Mahu akuanei, mahu apopo
Koi tae mai ki to kiri tipu

* Jour. Pol. Soc., pp. 89-98, 1895.

Ki to kiri ora, ki to mataniho
Kai tai roro i tai pupu
Tenei te rangi ka ruruku
Rukutia i o kiko
I o toto, i o uaua
E mahu—e !

And another :—

He nonota, he karawa, he au ika
Ko Tane tutakina te iwi
Tane tutakina te uaua
Tane tutakina te kiko
Tane tutakina te kiri
Tane tutakina te parapara
Tane tutakina te kapiti rangi
E mahu akuanei
E mahu apopo
E mahu a takiritanga o te ata.

The following is a very ancient Tuhoe method of treating a person who has been wounded, or has a bone fractured, or has been bruised by a fall, &c. The medicine-man would proceed to *takahi* the sufferer—*i.e.*, he would, as the person lay on the ground, place his left foot on his body, and repeat the invocation, termed *haruru* :—

Haruru ki tua
Haruru ki waho
Haruru ki runga ki tenei tangata.

The *tohunga* then repeats the *hono* charm (were it a burn, he would repeat the *whai wera*) :—

Tao ka tu
Ka tu ki hea ?
Ka tu ki runga
Ka tu ki waho
Ka tu ki te uaua nui o rangi
Ma wai e mimi
Ma tahito e mimi
Ma wai e mimi
Ma te atua e mimi
Taku kiri nei
Taku kiri tapu
He kiri ka toetoea
Ka haehaea ki te taha o te umu
Hai !
Ka toro te kiri ora
Ka mahu te kiri ora
Mahumahu akuanei
Mahumahu apopo.

The priest places his left foot on the patient's body because that foot is *tapu*. The *manea* of his left foot will give power or efficacy to the rite. *Manea* is a term applied to the *hau* of the human foot and footstep; it is the sacred vital principal of that member. The *manea* is the caretaker and salvation of man; its influence is very great.

In some cases the Maoris washed their wounds, and then applied a plaster of mud to exclude the air, and this was allowed to remain until the wound was well: *toetoe* grass was sometimes used instead of mud or clay. Small wounds were bruised with a stone to excite bleeding, and afterwards held over the smoke of certain specially selected herbs. Other applications in use were the gum of the *harakeke* (*Phormium tenax*), the oil of *titoki* and that of the *kohia* (*Passiflora tetrandra*), the gum of *Podocarpus ferruginea*, and a decoction of the leaves of *Piper excelsum* or *kawakawa*. These remedies have astringent, stimulant, or emollient properties. The Tuhoe tribes used a decoction made by boiling in water pieces of the bark of the *rata*-tree (*Metrosideros robusta*), and another made from the barks of the *rimu* (*Dacrydium cupressinum*) and *tawa* (*Nesodaphne tawa*) trees, the bark of the former being cut into pieces and that of the latter scraped, and the whole then boiled or steeped in water, together with some leaves of the *tutu* shrub (*Coriaria ruscifolia*).

A lotion made from the *namunamu* (*Geranium molle*), or from *piripiri*, by steeping them in hot water, was applied to open wounds, or rubbed on as an embrocation in case of contusion. The leaves are also applied as a poultice. The sap of *paewhenua* is applied to abrasions. When women who have been employed catching fish in the streams return with their feet scratched and sore, they find ease by applying leaves or plants heated before the fire: this process is known as *tapi*. The Tuhoe people sometimes cauterised wounds by holding near the cut a burning piece of dry *pirita* or supplejack (*Rhipogonum scandens*). In the case of a slight cut it was a common practice to urinate on the part, by which means swelling and inflammation were avoided. This is a very old procedure. The sap of young shoots of the *pirita* is used for wounds on dogs, when ripped by pigs.

During the Maori war many natives died of bullet wounds, for which their treatment was quite inadequate. In such cases they used sometimes to kill a dog, collect its blood, and make it hot by the aid of heated stones. This the patient drank as hot as possible, after which the *tohunga* repeated certain healing charms over him. In other cases the wounds mere merely washed and all foreign matter removed, and the limb placed in a sling (in the case of an injured arm) of flax, but no dressing or healing application of any kind was applied to the wound. Invocations to the gods were frequently repeated during the progress of healing. No married man or woman (except the wounded man's wife) was permitted to come near or see the patient during his illness, from a superstitious idea they held that by so doing the *atua* (demons) would be angry and retard the cure. The man was, in short, *tapu* until he recovered.

Throat Affections.

A choking person was relieved by means of such charms as the following, the sufferer being slapped on the back at the time of repetition :—

Kaitoa ano koe kia raoa
Nau ka ngau mai, ngau mai
Na i ka ngau atu, ngau atu
Te horo a te kawau
Horo mania, horo panuku
Horo, puhaina mai ki waho.

Or the following :—

Te Whai whiti raoa, tapa raoa
Kaitoa koe kia raoa
Na to kai tu, na to kai rere
Na to kai haere
Na to kai tama wahine
E hia ou ka ?
E rua ou kai
I horomia e koe
Ko nini, ko nana
Ko te patari o Wahieroa
Tama wa ine, whakaruakina
Raoa ki waho
Hokaikai ana ou ringaringa
Hokaikai ana ou waewae
Hotu nuku, hotu rangi
Hotu pakia
Whakaruakina
Nau mai ki waho.

Leprosy (Ngerengere).

Leprosy is found in nearly all the groups of islands of Polynesia, and, like other diseases introduced by foreign peoples, it at first increases rapidly in severity and frequency, and then gradually diminishes. Introduced into the Sandwich Islands by the Chinese *circa* 1848, leprosy quickly spread amongst the unfortunate Hawaiians until they gained the unenviable distinction of being one of the few native races more leprous than the Chinese. Fifty years after its introduction the disease was reported to be diminishing in severity. There are fears that the terrible record of leprosy in Hawaii is to be repeated in New Caledonia. Introduced in 1866 by a Chinaman, it has now spread to all the tribes: over four thousand cases are said to exist in the group, and the disease is rapidly increasing. The history of the introduction of leprosy into New Zealand is hidden in the mists of bygone centuries. Possibly it spread very rapidly at first, and then, as in the Sandwich Islands, having reached a maximum, commenced to decline, and has now almost entirely disappeared.

The classical account of leprosy among the Maoris was written

by Dr. Arthur S. Thomson* in 1854. He saw six cases. The disease, he writes, appears to have been more frequent early in this century. In 1854, if a native were asked if he knew any one ill with *ngerengere*, he would generally recollect one or two cases. Thomson knew a Maori who had seen ten cases in one village. Four cases were admitted to the Auckland Hospital in four years. At the present day only two or three cases of the native leprosy are known to exist among the Maoris. One case is reported to be at Tawata, a village on the Upper Wanganui River, and another at Rangiriri. Mr. W. E. Goffe reported the former case in the year 1901, but the following note from a recent newspaper probably refers to the same patient: "While in the Wanganui district lately [1903] he [Dr. Pomare, Native Health Officer] discovered an undeniable case of leprosy (the Maori *ngerengere*) at an up-river Maori settlement some fifteen miles above Wanganui Town. He made experiments which convinced him of the presence of the bacilli of leprosy. The sufferer has been isolated from the other Maoris. Certain other suspicious cases have from time to time been reported to Dr. Pomare, but the only ones in the colony proved to be leprosy are two Maoris, besides a Chinaman in Otago." It is, however, stated in the census of 1896 that "three cases of native leprosy exist." They are among the tribes residing in the districts north of Auckland, and they appeared to be of recent origin. One case of supposed leprosy was found also near Rotorua." Lepra gangrenosa is said to have occurred in all parts of New Zealand, but chiefly in the North Island in the Rotorua and Taupo districts.

Dr. Thomson described the disease as lepra gangrenosa, and his account, which I will now quote fully, is the only one that exists. He states that "*ngerengere*, or the lepra gangrenosa of the New-Zealanders, commences with a cutaneous eruption on the extremities, which extends over the trunk of the body. The eruption presents, in some parts, the oval patches and the copious exfoliation of a brown, scaly, morbid cuticle, observed in lepra vulgaris; the irregular patches of psoriasis; and, occasionally, the innumerable fissures, the elongated and extensive cracks, as in ichthyosis. This is accompanied with troublesome pricking and itching. The eruption goes on for months or years, increasing, and decreasing, and disappearing, partially or entirely. Gradually the hair on the eyebrows, eyelashes, whiskers, and beard falls out: not the hair of the head, the axillæ, or the pubes. The skin becomes livid, the eyeballs prominent, and a copious discharge of tears flows from them. The voice changes its tone; the face, nose, lips, the forehead and eyebrows, be-

*Brit. and For. Med. Chir. Review, 1854, p. 496.

come swollen and shining, but not tubercular. The skin is dry and harsh, but never anæsthetic. In about a year (it may be more or less) from the appearance of the eruption, a small boil, blister, or dry crack appears in the direction of the flexure, on the last joint of some of the fingers or toes. The soft parts ulcerate by a dry process, the phalanx falls away, and the part heals. Every year one or more of the joints fall off. There is sometimes pain along the lymphatics during this process. The other fingers or toes are dry, shining, and scabby, and the hand assumes a deformity somewhat like the *main-en-griffe* of nerve leprosy, the fingers being kept bent, the skin and tendons appear to contract, and the fingers are stiff; dislocation at some of the joints takes place. The acute sense of touch of the fingers is impaired, yet feeling is not quite lost, unless in the fingers about to drop off. Three, four, or more years may elapse before the whole of the toes or the fingers are lost. The appetite and digestion are good. The general health does not appeared to be impaired, and the body keeps up its usual weight. Sexual desire is diminished. Infants are never attacked; a boy of about twelve years of age has been seen affected. Most of the cases occur after puberty, and under thirty. Males appear to suffer more commonly than females. Several members of one family have died from it. It is not always, though usually, fatal. Its duration varies from one to five years."

Lepra gangrenosa was most familiar to the Maoris under the name *ngerengere*, or, when the face was much disfigured, *matangerengere* (*mata*, the face). Other names given by Tregear* as being applied to "a kind of leprosy" are *taiko*, *ringamutu*, *tuwheke*, and *tuwhenua*. The two latter also signified "covered with sores"; while *tuhawaiki* was "the native leprosy, a disease in which the extremities perish as though by frostbite." *Mutumutu* was "a kind of leprosy, whereby the first joint of a finger or toe falls off."

Leprosy was probably brought to New Zealand during the early migrations from Hawaiki, for there can be little doubt that the disease has been known to the Maoris for centuries. The term *tuhawaiki* or *tu-Hawaiki* suggests such a mode of introduction; and, as significant of the antiquity of the disease among them, may be cited the case of Te-whai-po (Incantations chanted at night), a legendary *tohunga* "born before the flood," whose "skin was not like other men's, but all white from leprosy." To the deified priest-physician, or demi-god, Maiwaho (or Tama-i-waho), "a most eminent man, and of great healing power and influence," "all offerings were made, ceremonies performed, and incantations chanted for the afflicted and leprous.

* "The Maori Comparative Dictionary."

It was he who taught Tawhaki many powerful incantations for the purpose of healing diseases."

"A singular belief," writes Elsdon Best, "exists among the old natives that the *ngerengere* disease is caused by the fish of the sea and by the land-birds. The aged Pio, of Ngatiawa, said to me, 'Another *atua* (demon, disease) of the Maori people is *ngerengere*. No one recovers from that disease. The persons (ancestors) who destroy the Maori people by that complaint are the fish of the ocean and the birds of the land. I say that the *ngerengere* is a plebeian complaint, unlike the *whewhe* (boils) and *hakihaki* (probably the itch), which are aristocratic complaints. If a person appears to be recovering from the *ngererengere*, that means that the causes of the disease have fled to the ocean, but ere long they will return and again assail the person: then he will die. This disease was first introduced by the Ngatiwhatua Tribe. It appeared at Taupo a long time ago, and the first person afflicted by it there was cast into a cave called Oremu.'" The Ngatiwhatua termed the disease *tuwhenua*.

At the present time the Maoris believe that *ngerengere* can be caused by the means of a magic rite termed *wero ngerengere*, and some assert that Te Whetu, a sorcerer at Taupo, still possesses this power. It has always been regarded as an *atua* (demon) disease inflicted by *makutu* (sorcery), or by their deified ancestors (*atua*) as punishment for infringement of the tribal *tapu* laws. Accordingly the leper was *tapued* and fed apart from healthy people. Some say that the natives believed the disease might be communicated by contact, but this is doubtful. They attribute its gradual disappearance to the introduction of Christianity, which has deprived their gods (*atua*) of the power of inflicting the malady.

The Maoris endeavoured to cure the disease by keeping the leper from sunrise to sunset in a vapour bath. During the process of steaming, the *tohunga* (priest-physician) repeated the *karakia* and charms especially applicable to such a malady. The diet during treatment was entirely vegetarian, no fish or pork being allowed. In spite of treatment all cases ran their course unchecked, although temporary relief from certain disagreeable symptoms was gained by using the vapour bath.

The following laments, composed by Te Rohu, of Taupo, when he was attacked by *ngerengere*, were sent to me by Mr. Elsdon Best:—

Ka ura mai te ra, ka kohi au he mahara
E hoa ma. E! He aha tenei hanga e te rau e pae
Tirohia mai ra aku pewa i taurite
Tenei ka titoko kai te ngaru whakakeo
E tere i Taupo
Ko te rite i taku kiri, ka ura mai i te rangi

Ka riro aku taonga i a Te Anga-a-mai i tawhiti
Tutata a Ngatiwhatua
Whakarongo mai ra, e koro
I Tongariro, i te puke ronaki
Te uru ki te whenua i mahue matau
Te tira o te taniwha
Me i hurihia iho, e au ana taku moe
Ki taku makau tipu—e!

Te Anga-a-mai is said to be the name of an ancestor who was the *ariki* (priestly healer) of the *ngerengere* disease: "*He tangi nana, mona e ngaua ana e te ngerengere*:—

Tera te ata iti hohoro mai koia
Matatu noa ana ko au nei anake
Kai te mura tonu o te pu a Rewi e ka ana
E pa! I heria mai i tua
Kia rongo atu au i te papa koura
Hai taoro iho mo te kino
I taku tinara ka tueketia
Ko tahau repera pai tonu tenei e te tangata
Ko te tika i to pono
Horahia mai ra, kia ui atu au
Ko wai to ingoa? Ko te ana i Oremu
Ko tau rakau kai te mata ngira tonu
Te ngotonga ki roto ra
Aue! Te mamae ra!

The Maoris placed implicit faith in omens, and recognised one that presaged an attack of leprosy. This was Io, the involuntary twitching of certain parts of the body. Io was a sign of good or evil. "If the Io were under either ear it was a sign of death. If it were at the side or below either eye it meant death. If it were above the eyes it was an omen that the person would lie smitten with leprosy or with contracted muscles.* The Maoris in the olden times worshipped Io, whom they regarded as the Supreme God, the creator of heaven and earth, whose name was held to be so sacred that none but the priest might utter it at certain times and places.† We presume that he communicated with the faithful by means of these involuntary twitchings, thus warning them of danger in time of war, of sickness, and of many other events which would soon come to pass.‡

Mr. Edward Shortland,§ Protector of Natives, came in contact with large numbers of Maoris, and, writing in 1843, he states that at Otakou, in the South Island, he saw for the first time a case of *tuhawaiki*. The victim, a young woman not more than thirty years of age, had lost her hands and toes, as though they

* "The Ancient History of the Maori," J. White, vol. ii., p. 2.

† "The Life and Times of Patuone," C. O. Davis, 1876, p. 13.

‡ The *io takiri* (omen) is not connected with Io the origin of all gods.—E. B.

§ "The Southern Districts of New Zealand," 1851, p. 13.

had been frost-bitten. The mutilated stumps had healed, but the limbs were shrivelled and darker than other parts of the body. He believed the disease to be rare, and had never seen a case in the North Island, nor to the south of Akaroa in the South Island.

The few sporadic cases of leprosy observed amongst the Maoris have been referred to by so many authors that undue importance has been attached to them, and the prevalence of this disease in the colony has been overestimated. That *ngerengere* was once very widespread in New Zealand is only a surmise, not supported by any facts. The steps now being taken by the Government to isolate the few remaining cases will doubtless result in the total disappearance of the disease.

FRACTURES.

Fractures were treated by encasing the limb with splints of bark (*papariki*), or the strongest parts of the flax-leaves. Compound fractures were sometimes carefully set, laid upon pillows, kept clean, and the pressure of the clothes kept off by wickerwork hoops. Sometimes the limbs were well set, and the splints very efficiently applied and kept in position until the bones were firmly united. The process of setting of the fracture was greatly facilitated by repeating this special invocation to the demi-god Tiki :—

O thou Tiki, give me thy girdle
As a bandage for this limb.
Come thou, bind it up,
Tie around it thy cords and make it right.
O thou flesh, be thou straight,
And ye sinews, be ye right,
And ye bones, join ye, join ye.

Healing of the broken bone was hastened by repeating a charm known as a *hono*, such as the following :—

Tutakina i ou iwi
Tutakina i ou toto
Tutakina i ou mongamonga tena te rangi
Ka tutaki, tena te papa ka whena.

which, being translated, is :—

Close up your bones,
Close up your blood,
Close up your marrow, and be united as the heavens,
And let your bones be strong as the earth.

BURNS AND SCALDS.

The Maoris apply the feathery plumes of the *toetoe* grass (*Arundo conspicua*) in the form of a poultice to a scalded surface, and, while applying it, repeat the following *karakia* or prayer to Tiki :—

Return, O ye gods of the land,
And ye gods of the sea,
Come and save, that this man
May work for us, O Tiki,
For you and me.
Heal him, O heal!
If it had been kindled by me on Hawaiki
It might have been extinguished.
O thou skin, be not diseased by this evil,
Cease thou heat, be cured thou burn,
Be thou extinguished thou fire
Of the god of Hawaiki;
Ye lakes of heaven give coolness to his skin;
Thou rain, thou hail, come to his skin;
Ye shells and cool stones, come to his skin;
Ye springs of Hawaiki, Rarotonga, and Aotea
Come to this skin and cause it to be damp;
Be healed thou skin, be healed.

Or this charm might be considered sufficient:—

I wera i te aha?
I wera i te ahi
Ahi a wai?
Ahi a Mahuika
Tikina mai, whakaorahia
Hei mahi kai ma taua
Wera iti, wera rahi,
Wera kia raupapa.
Maku e whakaihi,
Maku e whakamana.

Which may be translated thus:—

What caused the burn?
Fire caused the burn.
Fire kindled by whom?
Fire kindled by Mahuika [fire goddess].
Come and fetch some [fire], spread it out,
To be a slave to dress food for both of us.
Small burn, large burn,
Burn, be crusted over with skin.
I will make it sacred,
I will make it effective.

The Tuhoe people used the following charm, termed a *whai wera*, supposed to have been derived from their great ancestor Tawhaki:—

Te whai, te whai
Te turitaku, te poko taringa
Te ruahine matua.
I wera koe ki hea?
I wera ki Tarahanga a ue Tawhaki
Hoki taku tama
Ka tokia to kiri ki te wai ti,
Ki te wai ta
Ka ka te motumotu
Ka ka te ngarahu
He wera iti te wera

He wera rahi te wera
He wera kaupapa
Mahu akuanei, mahu apopo
Mahu a takiritanga o te ata.

In addition to these *karakia* and charms the natives made applications of cold substances, such as pebbles, shells, &c., or placed the burnt part in cool water. They also used the ashes of burnt "tussac" grass, and a lotion prepared by boiling the leaves of the plant *kopakopa* (*Plantago major*), or from the bruised leaves of the *kopata* (*Pelargonium australe*). As an emollient they used the white gum called *manna* by the colonists, gathered from the *manuka*, or tea-tree (*Leptospermum scoparium*). The inner bark of the *rimu* (*Dacrydium cupressimum*), bruised into a pulp, was applied to burns. The viscous gum or mucilage of the flax-plant (*harakeke*) afforded an excellent protective, and, from its alkaline properties, sedative application for wounds and burns.

SKIN-DISEASES.

Boils (*whewhe*) were of common occurrence in former times, but are not so frequent now owing to improved sanitary conditions. The Maoris attributed this complaint to eating decomposed and fermented corn, of which they were extremely fond. Other etiological factors were the custom of washing in small, filthy, common bathing-pools, the crowding together of nude or scantily clothed people, with their boils often discharging and polluting the floors and mats of the huts. It is not surprising that epidemics of boils sometimes occurred. The disease runs the same course as in the case of white men, except when the native is physically weak from starvation, &c., when death sometimes occurs from fever and exhaustion. This was an especially common termination in weakly children.

As an external application they sometimes used poultices of scraped roots, such as those of *harakeke* (*Phormium tenax*), also hot leaves. A decoction made from the *rauriki* (*Sonchus*), and the expressed juice of the "pig's-ear" (*Mesembryanthemum* sp.) were used locally, while as a "tonic" they took internally an infusion of the leaves of the *kawakawa* shrub (*Piper excelsum*). When mature, or sometimes long before, they incised the boil with a sharp edge of a shell, an obsidian splint, a sharp-pointed stick, or a thorn, and applied firm presssure so as to force out the core (*whatu*). Finally human milk was used as a wash to complete the cure.

Ulcers (*mate poka*), simple, venereal, and tuberculous (*tipu*), were caused in some cases by *atua*—as, for instance, *tara-kumukumu*, an ulcer caused by a demon of the same name, and occurring on the thighs. The cure was to wash with warm water.

Also, *papaka*, or *he atua*, likewise attributed to a special demon. This disease originated with Te Whatu-i-apiti Hapu of Heretaunga, and consists of a series of ulcers which break out on various parts of the body, sometimes causing death. No remedy was used to relieve the complaint. To ulcerated surfaces they applied as a poultice the leaves and tender shoots of the astringent *koromiko* (*Veronica salicifolia*), the boiled leaves of the *kopakopa* (*Plantago major*), or the *poroporo* leaf (*Solanum laciniatum*). The bark of the *pukatea* (*Atherosperma novæ-zelandiæ*) steeped in water, after removing the outer rind, formed a healing lotion for tuberculous and chronic ulcers. The *miro* or black-pine (*Podocarpus ferruginea*) yields a gum used for the same complaints. A favourite method also was to bathe the affected parts in the hot sulphur and siliceous springs of Rotorua, Taupo, and other places in that district.

Mate pokapoka is a general term which includes all diseases that cause ulceration and destruction of the skin. It is applied to ulcers, syphilitic skin eruptions, *patito* (ringworm), and *hura*. "This latter," says Elsdon Best, "is a very disfiguring complaint, of which I do not know the European name, and seems generally to attack the neck and side of the head, which get into a dreadful state. When cured it leaves the skin much marked, drawn, and seamed. This complaint is also termed *hore;* it is said to have been common here before the arrival of Europeans." From so meagre a description of the lesion one cannot do more than suggest the possibility of *hura* being a tuberculous skin ulceration. *Patito* is a disease of the scalp, commonly seen in children. The term is also applied to ringworm, but probably the latter may be a modern application. The following is the Tuhoe method of treating these complaints. "Some wood-ashes are placed in a small vessel, and over them is poured a liquid made by boiling or steeping pieces of the bark of *kowhai* (*Edwarsia microphylla*) and *manuka* (*Leptospermum scoparium*) trees in water. This mixture is stirred and allowed to dry, when it sets hard. When used, the skin is scored with a sharp instrument, and some of the block of ashes is scraped off and rubbed into the scored lines. This ash-mixture is termed *pureke*.

"This scoring of the skin is very common among the Maoris. It is done for headache and almost any pains affecting the body. The skin is scored with a needle, and then either painkiller or vinegar is rubbed in, as a rule."

Maihi (dandruff) is treated like *mate pokapoka* by rubbing ashes on the scalp.

Hakihaki (scabies, or the itch), a contagious animal-parasitic disease, a sort of eczema or dermatitis, caused by the presence of an animalcule, the itch-mite, in the skin, was one of the com-

monest and most troublesome complaints from which the Maoris suffered. This is not to be wondered at when one notices their aversion to soap-and-water, the custom of living crowded together in common sleeping-houses, and their close contact with such domestic animals as dogs and pigs. This distressing malady was formerly treated by the use of lotion applied to the affected parts. The outer bark of the *manono* (*Coprosma grandifolia*) was scraped off, and the inner bark obtained. This was squeezed in order to express the sap, which was applied, the affected regions being first rubbed with oil or fat in order to soften the cuticle and expose the inflamed spots. The inner bark of the *kowhai* and the *poroporo* were used for the same complaint. As internal remedies they took *rimu-roa* (*Laminaria* sp.), a long marine alga which grows on the rocks on the sea-coast; its tender end was roasted and eaten, as were also the young shoots of the *kareao* plant. These latter medicines were probably totally useless, but some relief was doubtless obtained from an ointment or salve prepared by drying certain parts of the *kohu-kohu* (*Pittosporum obcordatum*) in the sun, pounding them into a dust, and finally mixing into a paste with *hinu-kohia* oil, made from the seeds of *Passiflora tetrandra*.

Pakewakewa, probably a form of eczema, was attributed (erroneously, no doubt) by the natives to the use by a woman of her own or another woman's clothing for a pillow. "The skin of her face and neck becomes rough (*whekewheke*), possibly pimply, or covered with eruptions. *Te mutunga iho o te pakewakewa, he kiri hoko* (the *pakewakewa* ends in, or leads to, the *kiri hoko*)." The latter disease causes the affected parts to turn white. This blotched skin is particularly repulsive in appearance, but is not identical with *kotureture*. The treatment is to rub the parts with oil.

Overindulgence in the favourite Maori delicacy, potted mutton-bird, caused an eruption about the arms and thighs, accompanied by intolerable itching, which, however, soon disappeared with the aid of cleanliness and abstinence from such gross diet. This eczematous eruption was no doubt much aggravated, if not partly caused, by the repeated application to the skin of the rancid fat in which the bird was potted, that irritating substance being unavoidably transferred from the hands to different parts of the body.

The *paipai*, a pre-European cutaneous disease, which is also called *tokatoka* and *patuheni*, was perhaps eczema intertrigo. It was cured by means of the smoke of a fire of *totara* wood (*Podocarpus totara*). The term *paipai* is also given to gonorrhœa, while *tokatoka* is one of the Maori designations of syphilis.

Hawaniwani was a skin-disease affecting children. The skin

became covered with crusted sores. The usual remedies were *kokomuka* (*i.e.*, *koromiko*), a preparation of the shrub *hanehane* (*Geniostoma ligustrifolium*), and the oil expressed from the seeds of the *titoki*-tree.

Eczema of the scalp was treated with the *kohu-kohu* ointment used for the itch, and with a lotion made from the *pukatea* plant.

Ringworm (*muna*, *patito*) was washed with the lotion prepared from the *rata* bark, and a preparation of the root of *harakeke* (flax-plant).

Eye-diseases.

The native custom of lighting fires in their huts and closing all the apertures by which the smoke might find egress was naturally productive of much ocular and pulmonary irritation in those who passed the long winter nights in such a vitiated atmosphere. Weak eyes (*toretore*), watery eyes (*toriwai*), styes, or boils of the eyelid (*kiritona*), ectropion, or eversion of the eyelids (*kirikiritona*, or *karu-kowhiti*), and other inflammatory conditions of the superficial parts of the eye were of common occurrence. The process of tattooing the eyelids, both from the mechanical injury and the subsequent inflammatory processes, must also have resulted at times in serious ocular disease.

Rewha (squint) and *paua* (corneal opacities ?) were sometimes seen, while blindness (*pura*, *parewha*, or *matapo*) was not unknown.

The term *toriwai* is applied to weakness of the eyes with excessive lachrymation, for the relief of which the Maoris use the sap of the creeper *aka kura* (*Metrosideros scandens*). A piece of the creeper is cut into short lengths, one end of which is placed in the mouth, and by blowing the sap is forced out at the other end: this is collected and applied to the eyes. The sap of *kopukupuku* is used in cases of *toretore*, as are also the green oil of the *titoki*-tree (*Alectryon excelsum*), and the bruised pith of the *mamaku* (*Cyathea medullara*).

A *kiritona* or stye on the eyelid, when *maoa*, or ripe, is squeezed to express the core (*whatu*, or *nganga*), and then bathed with human milk.

Dimness of vision, and perhaps blindness, were attributed sometimes to the *atuakahu*, but the causes leading to inflammatory conditions of the conjunctiva must have been quite obvious to the natives. For the relief of blindness (*matapo*, eye-darkness) certain charms were recited, and Taylor* gives the following example :—

Irimata, Irimata
Weromata, Weromata,
He wai o mata ki te ra,

* "Te Ika a Maui, p. 39.

He hurumai ra,
He pa ko rirerire,
Hae tahi ki te mata,
O Watitiri rua ki te
Mata O Watitiri
Titiromai ra,
Kakanomai ra,
Ki te mata ora,
Ki tu mata o Rehua.

Which may be translated thus :—

Wave before your eyes, wave before your eyes.
Thou smitten blind, thou smitten blind,
Be your eyes bright
Like the sun that rises there,
Since you are so greatly afflicted,
Once to the eyes of Waititiri
Twice to the eyes of Watitiri.
Look this way,
Glance this way,
With your healed eyes,
With your star-like eyes.

This was the incantation repeated by the god Tawhaki in response to the appeal of the blind Wai-tiri, or Waititiri. She said to him, " Perform the ceremonies and cure my eyes." He at once complied. Taking clay and kneading it with his spittle, he rubbed it in her eyes, repeating meanwhile the above incantation. The result was highly satisfactory, the patient remarking, " Aye, aye, my eyes are cured, my grandson."

Another method of curing *matapo* is thus recorded by White in his lectures on " Maori Customs and Superstitions ": " The priestly physician ties round his own waist the twigs of *kawakawa* (*Piper excelsum*) and *karamu* (*Coprosma*, var. species) as an apron, and, standing in front of his patient, who is sitting up, he waves a branch of one or other of the same shrubs before the man's face, saying :—

Thou sun now coming,
Red in thy coming—give light here.
Thou moon now coming,
In thy flight look on this man,
Now dimly seeing the gods are moving.
Welcome, come ye forth,
From the eyeballs the red waters come,
Give light, give strength,
Give life—life now come.

TOOTHACHE.

The teeth were classified into cutting-teeth, or incisors (*niho-tapahi*), eye-teeth (*niho-kata*), and double teeth (*niho-pu*, or *niho-purakau*). Milk-teeth were named *niho-kaiu* ; uneven or overlapping teeth, *niho-tapiki* ; and a broken tooth, *niho-hawa*.

In former times toothache and gum-boils were of frequent occurrence, but until the advent of the colonist decayed teeth were rarely seen. In a series of eighty-three skulls examined by Professor Scott,* of the Otago University, the teeth were all free from the slightest sign of dental caries. In seven he noted the cavities of alveolar abscesses (*tunga-puku*). "Six of these cavities are found in the upper jaw, one in the lower; and most of them have been at the roots of either the incisor or premolar teeth."

Toothache (*niho-tunga*, *tunga-raupapa*, or *mamae o nga niho*) was attributed by the Maoris, as it is by many peoples of low culture, to the gnawing of a grub, worm, maggot, or insect. The *tunga* is the grub of a species of beetle inhabiting decayed wood, and *niho-tunga* is the term applied by the natives to both toothache and decayed teeth, while *tunga-puku* is an alveolar abscess or gum-boil.

One method of treating toothache is to place one end of a small stick against the tooth and then to strike the other end a smart tap with another stick. The Australian blacks extracted incisor teeth by a similar procedure in their initiation ceremonies, but we are not aware that the Maoris ever resorted to teeth-extraction in odontalgia. Another cure is for the person to hold some of his urine in his mouth for a time. This is done early in the morning, and is supposed to kill the *ngarara* (reptile) whose burrowing causes the pain. A modern cure is to place in the hollow tooth a piece of the "chestnut" (*maki*) of a horse's leg; but the patient must not see the *maki*, or no cure will be effected: he must get some one else to procure it and place it in his tooth. The application to the affected tooth of a piece of the tough, leathery cocoon of a certain caterpillar, which is found attached to branches of the *manuka* shrub, is another reputed remedy. The most efficient of their herbal remedies was perhaps the New Zealand pepper (*Macropiper excelsum*), the leaves and berries of which have a warm aromatic flavour. The leaves and root were chewed as a remedy for toothache. This plant closely resembles the *kava* (*Piper methysticum*) of Polynesia, but its root does not possess similar sedative or narcotic powers. A very strong decoction of *pukatea* bark held in the mouth for some time relieves toothache, as does also the bark of the *ngaio*-tree (*Myoporum lætum*). The sap of a plant known as *kopukupuku* or *maruru* is also used. The leaves are clenched between the teeth of the suffering person, who is then told to sleep, and when he awakens the pain will have disappeared. But, as in the former case, the sufferer must not see the leaves, or they will lose their medicinal power.

* Trans. N.Z. Inst., 1893, p. 21.

In olden times charms were repeated in order to cure toothache, as also others to cause children's teeth to grow. A favourite charm was this :—

He tuna, he tara
Pu-ano-ano, pu-are-are.
Mau e kai i te upoko
O taua tara-tu.

Which, being translated, is :—

An eel, a spiny back,
True indeed, indeed : true in sooth, in sooth.
You must eat the head
Of said spiny back.

Scotch and Welsh peasants attribute toothache to the presence of a worm, and, like the Maoris, sometimes endeavour to exorcise it by muttered charm or incantation.

INSANITY.

General.

Maori philosophers regard the body and the mind as separate entities. The spirit, or what we regard as the soul, is with them not a single but a compound intangible and invisible spiritual essence. We have already referred to the *hau* and the *wairua*, the vital essence and the dream-ghost, as component parts of man's soul, and it is interesting to note here that the Maori metaphysician locates intellectuality in the *hau*, and not, as we do, in the cerebrum, and regards the *wairua* as the source of all moral ideas, prompting a person to perform good or evil actions. These savages, although so advanced in the region of abstract conception, had not progressed so far as to be able to attribute disease to derangement of organic function ; and insanity was not regarded by them as the result of any morbid condition of the body or spirit : mental aberration was due to the subtle entrance of some hostile spirit—the lunatic was the victim of sorcery or the plaything of an evil *atua*. This messenger from the gods, or ancestral ghost, or malignant *atua*, is heard speaking during the mutterings and ravings of the lunatic ; it is this *atua* which throws him to the ground, jerks and writhes him in convulsions, makes him leap upon the bystanders with a giant's strength and a wild beast's ferocity—impels him, with distorted face and frantic gesture, and peculiar unnatural voice, to pour forth wild incoherent raving, and even in his fury to rush and jump headlong over a cliff into the sea.

All persons who were the subjects of " demoniacal possession " did not behave in this violent manner. For instance, a *kaupapa*, or person who is occasionally visited by an ancestral spirit, and who is its medium of communication with the living, might, on the arrival of his familiar spirit, merely commence to tremble

and behave in a stupid manner, giving forth prophecies in a squeaking, hissing, or ventriloquistic voice. Or, if he wished to attract attention and gain the reputation of being a powerful *tohunga*, he might, on a suitable opportunity, demonstrate the power of his *atua* by undergoing a series of violent bodily contortions and facial grimaces, accompanied by the emission of prophecies in an unnatural voice.

A magic rite called *whaka-tihaha* was practised by the sorcerer to induce madness in the enemies of his clients. This species of *makutu* was generally directed against thieves, and women who repelled the amorous advances of undesirable suitors.

Of the manifestations of mental disorders among the Maoris in the early years of colonisation we have the observations of two medical men who had at that time an intimate and extensive acquaintance with the natives. Dr. Arthur S. Thomson, writing in 1854, stated that insanity and idiocy were not of frequent occurrence in the aboriginal villages. In the extensive district of Poverty Bay, out of 2,145 persons, there were, in 1849, two idiots and one insane person; and at Tauranga, in the Bay of Plenty, in 1849, out of 2,411 souls, there was no insane or idiotic person. Temporary fits of insanity, the result of chronic and acute disease, were occasionally observed; but the above data show that true insanity and idiocy were rare. Dr. Thomson attributed most of the cases of insanity which came under his notice to defective formation of the skull, mechanical injury, old age, or superstition: all of which causes it is not in their power to prevent. He mentions the case of an old Maori, then in the Auckland Asylum, who had been "mad" several times. The condition was caused by excessive drinking. His tribe lived at a distance from Auckland. He periodically escaped from his friends, and, coming to town, drank himself into a state of *delirium tremens*, with suicidal tendencies. A few weeks' detention in the asylum resulted in a cure. Dr. Thomson observes that this was the only instance he had ever heard of a strong desire for spirits among the aborigines. This contrasts strongly with the state of affairs in Australia, where it is possible to trace the development of insanity in the tribes (N.S.W.) from a time when lunacy was extremely rare among them to one in which it is almost twice as common as among the white inhabitants in the same territory. A considerable portion of these cases were due to drink; four or five were due to imprisonment, but the chief factor was doubtless "civilisation."* In 1864 Sir John (then Dr.) Tuke also referred to the comparative rarity of mental disease among the Maoris. The varieties of mental alienation most frequently met with by him were, in the order

* Trans. Austral. Med. Congress, 1889, p. 857.

of their occurrence—idiocy; senile mania and dementia; morbid impulse, such as homicidal and suicidal mania; and general paralysis of the insane. "All the forms of mania, monomania, and melancholia observable," he says, "are purely emotional—a fact which might be anticipated when their peculiarly excitable temperament is taken into account. An orator at one of their tribal meetings, when wound up to the proper pitch, might be readily taken for a maniac by one not conversant with their usages; and the same person might easily mistake a paroxysm of passion, as evinced by a native on very slight provocation, for the ungovernable rage of the insane."

Recently I received a communication from Dr. E. G. Levinge, Medical Superintendent of the Christchurch Asylum, in which he stated that, although there were two or three considerable Maori settlements in the district embraced by his asylum, yet only five or six Maoris had been admitted during a period of fifteen years. He attributes their comparative immunity to their simple mode of life, and comparative freedom from anxiety, worry, and intemperance.

Dr. Tuke's early observations have been recently confirmed by an authority who declares that the most common form of mental disease observed amongst the Maoris is congenital amentia, in all its varieties, from mere weakness of intellect to the drivelling idiot, and, as elsewhere, it is characterized by the small head and retreating brow; and next, senile dementia, with occasional fits of maniacal passion. A considerable portion of those natives, he adds, who reach advanced age settle down into a torpid, inanimate state.

Epilepsy is uncommon in Polynesia, but has been observed at Tahiti, New Caledonia, Hawaii, Fiji, Tonga, and among the Australian blacks. It is said to be unknown among the Maoris.

Persons who were insane (*porangi*, *porangitangi*, *porewarewa*, *haurangi*, *potete*), or demented and foolish (*wairangi*), or temporarily possessed by a demon (*apa*), were, if not violent or showing any homicidal tendencies, allowed to wander aimlessly about, without restraint. They were often supposed to have powers of second sight, and in such cases were treated with attention and respect.

When a man became mad (*porangi*) he was taken to a *tohunga*, who first made an examination as to the cause of the disease. He and the sick man then went to the sacred pool, and the medicine-man, stripping off his clothes, took in his hand an obsidian flint. First he cut off hair from the left side of the sick man's head, and then a lock from the top of the head. The flint was then placed on the ground, and upon it the lock of hair which had been cut from the top of the head, the other lock being

held aloft in the left hand of the *tohunga*, while in his right hand he held a common stone, which was also raised aloft, while the following *karakia* was being repeated by him :—

Tu, divide; Tu, split;
This is the Waitapu flint,
Now about to cry aloud
To the moon of ill omen.

Then the priest breathed on the flint, and smashed it with the stone in his right hand. After this he selected a shoot of the *toetoe* plant, and pulled it up, and to it fastened the two locks of hair. Then, diving into the water, he let go the *toetoe* and locks of hair, and when they floated on the surface he commenced his great incantation, thus :—

This is the Tui of Tu-i-rawea,
This is the Tui of Uenuku.
Where lies your sin ?
Was eating *kutu* [lice] your fault ?
Was sitting on *tapu* ground your fault ?
Explain the mystery,
Explain, divulge.
Take away the fault from the head
Of the *atua* who afflicts this man.
Take away the disease,
And the power of the sorcerer.
Turn your supernatural power against your *tohunga*,
And your *whaiwhaia* [charm].
Give me the charm
To make as cooked food.
Your demon desecrated,
Your sacredness, your incantation,
Your sacred-place-dwelling *atua*,
Your house-dwelling *atua*,
Give me to cook for food.
Your sacredness is desecrated by me.
The rays of the sun,
The brave of the world,
The supernatural power, give me.
Let your *atua* and your *tapu*
Be food for me to eat.
Let the head of the magician
Be baked in the oven,
Served up for food for me,
Dead, and gone to Hades.

The latter part of this *karakia* consists of a series of the most powerful insults and curses that a Maori could invent to direct against an enemy. All things most holy to the New-Zealander—his ancestral spirits (*atua*); the most sacred part of the body, the head; his most cherished virtues, his *mana* (prestige); his *tapu*—are all foully cursed and desecrated, and this is done to nullify the force of his black magic (*whaiwhaia*), which is supposed to have rendered the patient mad. From the early part of this interesting incantation we learn that insanity was supposed to

result from the breaking of the *tapu* laws, or the spells of the hostile wizard.

In some cases herbs were given to the lunatic (*keka*), such as the juice of the pith of the *tutu*-tree (*Coriaria rusciſolia*).

Rapidly Fatal Melancholia of the South Sea Islanders.

Every one who has dipped into the somewhat extensive literature concerning Polynesia and the Polynesians has read strange stories of strong men sitting down and " willing themselves to death " because they imagined themselves the victims of the sorcerer's art, or that they were under the ban of the gods. This fatalistic tendency which has been so often observed, not only in the Polynesians proper, but also in the Maoris, Australian aborigines, and Melanesians, and which leads to death after a shorter or longer interval of deep depression and lack of desire to live, is due to the effects of superstitious fear acting on a peculiarly susceptible nervous system.

A Maori who unwittingly desecrates a sacred (*tapued*) spot is seized with a terrible superstitious fear. He has incurred the anger of the tribal or family gods. He feels that his sin is unpardonable, and the unhappy wretch rolls himself up in his mat, refuses sustenance, and soon dies. His death is not due to starvation, but to severe mental and consequent physical depression. Dr. Batty Tuke knew of a case which proved fatal in less than three days, the subject previously being apparently in rude health, and possessing a Herculean frame. He also mentions a second case where a Maori, to all appearance well, and who certainly was not suffering from any disease of the thoracic viscera, became melancholy, apparently chagrined at life ; he said he was going to die, and die he did within ten days. The above was rather a protracted case ; there being many well-authenticated cases, he adds, where the victim died in three or four days. Taylor relates that the great chief Taonui once lost his tinder-box, which was found by some common men, several of whom lighted their pipes from it, and that these men actually died from this form of melancholia, induced by fear, when they discovered to whom it belonged. Shortland, I believe, relates somewhere that when travelling with a Maori guide they sat by the wayside to rest, and while conversing with his dusky companion a green lizard ran over the guide's foot. The lizard was at once captured by the Maori, who examined it carefully for some minutes and then let it run away. He afterwards casually declared that he would die in eight days. The lizard, he explained, was an incarnate ancestral soul, and had come to warn him that he must die. There were eight black spots on the creature's back, and these indicated the day of his death.

The native went about as usual for seven days, and on the evening of the seventh wrapped himself in his mat and was found dead next morning. The gods had called him to the great world of the spirits. Last year the well-known Waikato chief Hori Kukutai died. He was extremely superstitious, and he likewise imagined he heard the spirit-voices calling him, and prepared to obey the summons. Some little time before he died, Lord Ranfurly, the Governor of this colony, made a trip round the Province of Auckland in the Government yacht, and Kukutai was one of the party. The aged chief enjoyed himself immensely till the vessel approached the North Cape; he was a good sailor, and in excellent spirits. As, however, they approached Te Reinga, the legendary cliff where the souls of the dead natives plunge through the portal of Hades and gain entrance to the spirit underworld, Hori began to get depressed, and to sink deeper and deeper into a state of profound melancholy. He said the lapping of the water and the sighing of the wind were the voices of his dead ancestors calling him. To appease them, he threw overboard a shirt belonging to one of the Crown Ministers, and quickly followed this by some articles of attire belonging to other members of the ship's company. His own clothes were at first reserved, but as his symptoms increased he would have thrown them overboard too; and it was feared that he would have jumped over the side had he not been carefully watched and attended by those on board. As it was, so great was his nervous prostration that grave fears were entertained that he might succumb.

Mr. Andrew Lang* relates the following interesting case occurring in Melanesia. "The story is vouched for by Mr. J. J. Atkinson, late of Noumea, New Caledonia. To him one day a Kanaka of his acquaintance paid a visit, and seemed loth to go away. He took leave, returned, and took leave again, till Mr. Atkinson asked him the reason of his behaviour. He then explained that he was about to die, and would never see his English friend again. As he seemed in perfect health, Mr. Atkinson rallied him on his hypochondria; but the poor fellow replied that his fate was sealed. He had lately met in the wood one whom he took for the Kanaka girl of his heart; but he became aware too late that she was no mortal woman, but a wood-spirit in the guise of the beloved. The result would be his death within three days; and, as a matter of fact, he died."

This peculiar form of melancholia which has a fatal termination when affecting persons free from obvious organic disease is a most potent and frequent cause of death in times of epidemic sickness. Thus, in the great pestilence called *okuu*, which swept

* "Myth, Ritual, and Religion," vol. i., p. 105.

over the Sandwich Islands in 1807, great multitudes succumbed. The name *okuu* was given to the epidemic because the people *okuu wale aku no i ka uhane—i.e.*, dismissed freely their souls and died.

As illustrations of the despondent state of mind into which the Maori often fell when seized with what he believed to be an incurable disease, sent by the gods in punishment for sin, we may cite the following laments :—

Alas, thou canst not find a remedy,
The gods have otherwise decreed ; Whiro [a god] by his
Axe has all my bones disjointed, and I am
Torn asunder as a branch snapt from its
Parent stem by some rude blast, and fal'ing
With a crash is rent in pieces.
I did it ; I brought this death
Upon myself in meddling with the sacred things
Which e'er displease the gods : and now
As in a desert I'm bereft of every succour.
Emaciated and folorn, wracked with
Pain of body and distress of mind, I turn me
Round to die.

Such was the song of the daughter of Kikohiko, chief of the tribe Ngatiwhatua, of Kaipara. In another lament by a chieftainess, who imagined that she was also a helpless victim of evil demons, we find these lines :—

Ah, this animal Mokoroa has
Thrust his teeth into my flesh, and
Grasped my body with his numerous
Teeth, and thus I am being eaten up.
The pain that wracks my body is like
An army passing on, each wounding
As he passes.
Aye, there's little
Hope of my recovery : I'm hastening to the dust,
To appease the gods, who haunt my spirit hence.

The fatalistic frame of mind into which these superstitious young women drifted would render them unfit subjects for medicinal treatment, and would place them even beyond the power of the most potent *karakia* and rites of the tribal sorcerers. Superadded to their organic disease was the condition of rapidly fatal melancholia, or *awhireinga*, the latter term signifying "to embrace or draw near to the region of spirits, or, to court death."

Mr. C. J. Du Ve* relates that "in the year 1860 a Maneroo (Australian) black died in his service. The day before he died, having been ill some time, he said that in the night his father, his father's friend, and a female spirit he could not recognise had come to him and said that he would die next day, and that they would wait for him." Mr. Fison, who prints this tale

* A. Lang, "Myth, Ritual, and Religion," vol. i., p. 106.

in his "Kamilaroi and Kurnai," adds, "I could give many similar instances which have come within my own knowledge among the Fijians, and, strange to say, the dying man in all these cases kept his appointment with the ghosts to the very day."

Another phase of this fatal melancholia is frequently seen in Fijian girls and youths who have sickened and died after the sudden discovery and disruption of an amorous intrigue: an interesting example of the profound mental shock which may be experienced by people who are generally unimpressionable. Then again, when a Polynesian becomes ill of any save the most ordinary malady he makes little or no struggle for life, but becomes melancholic, and perhaps fixes the date of his death, and dies on the appointed day. In times of epidemic sickness these islanders become what the Fijians call *taqaya* (overwhelmed, dismayed, cowed), abandoning all hope of living, and becoming incapable of any effort to save themselves or others.

Profound and often fatal melancholy was also induced in people who imagined or were told they had been bewitched. This was shown in a striking way when a sorcerer informed a white man at Hawaii that he was about to bewitch him to death (*anaana*), and the white man replied that he too could bewitch. The priest, supposing that the white man was practising black arts against him, sank into despondency and despair and finally died. Codrington mentions a somewhat similar case, where a native of Ava, in Melanesia, had declared his intention of bewitching to death an enemy with his magic *tamatetiqua*, or "ghost-shooter," at an approaching feast; but he would not tell who it was he intended to kill. To add force to the ghostly discharge he fasted many days before the feast began, and became so weak that he had to be carried to the dancing-place. There he sat, a fearful object, black with dirt and wasted to a skeleton with fasting, his "ghost-shooter" grasped in his bony hand and closed with his thumb, and his bleary eye watching for his enemy. Every man trembled as he danced by him. After a while, bewildered and dazed by the tumult, he presented his magic bamboo charm at the wrong man. The man he aimed at fell at once to the ground, and the dancers stopped. Then the sorcerer saw his mistake, and that the wrong man was bewitched, and his distress was great; but the man that had fallen was ready to expire, but after the true state of affairs was explained to him he took courage again to live, and presently revived. No doubt, adds Codrington, he would have died if the mistake had not been known.

Examples of deaths from this form of fright, technically called "thanatomania" (death-mania), might be cited *ad infinitum* from the anthropological records of the Maoris, South

Sea Islanders, Melanesians, and Australian native races. And although death is not due in such cases to the true "rapidly fatal melancholia of the South Sea Islanders," yet the condition is a nearly allied one.

No one, I think, has attempted to explain the rationale of death from this curious form of melancholia. The victim is popularly supposed to "will himself to death," but we cannot seriously attribute the fatal issue to the will-force of the savage. The chief characteristic of the Maori mind is its instability. His mental equilibrium is at the mercy of a thousand daily incidents; he is the plaything of outside circumstances. His brain not having been subject to a prolonged course of moral and intellectual culture, he lacks that mental balance which is the characteristic of highly civilised peoples. He is incapable of governing himself; he will laugh or cry for the most futile reasons; explosions of joy or sadness may disappear with him in an instant. A Maori chief once burst into a violent fit of tears because some sailors had covered one of his smart cloaks with flour—the insult completely overpowered him. I have seen a crowd of weeping mourners at a Maori *tangi* suddenly burst forth into yells of delight and laughter at the grimaces and grotesque postures of some dancing-women. A Tahitian woman who was crying bitterly because her child had just died broke out into laughter when she saw Captain Bligh. Thus the savage is liable to sudden fits of happiness or of depression.

In that curious mental condition called "South Sea Island hysteria," the patient, after a preliminary period of depression, suddenly becomes violently excited, seizes a knife or some weapon, and rushes through the village slashing at everybody he meets and doing no end of damage, until he finally falls exhausted. If he cannot find a knife, he might rush to the ocean reef and fling himself into the water and swim for miles, until rescued or drowned. This violent hysterical excitement is common to all the islands, as is the opposite condition of sudden and profound mental depression. A *pakeha* once attended a Maori spiritualistic seance at which the local *tohunga* had promised to call up the spirit of a noted young chief recently killed in battle. He thus describes the proceedings: "At night we all met the priest in the large house. The priest retired to the darkest corner. All was expectation, and the silence was only broken by the sobbing of the sister and other female relations of the dead man. They were in an agony of excitement, agitation, and grief. Suddenly, without the slightest warning, a voice came out of the darkness. 'Salutation! Salutation to you all! Salutation! Salutation to you, my tribe! Family, I salute you! Friends, I salute you!' A cry of despair and affection came from the sister of the dead

chief. At the same instant another female voice was heard from a young girl who was held by the wrists by two young men, her brothers: 'Is it you? Is it you? Truly is it you? *Aue, aue!* they hold me, they restrain me, they watch me, but I go to you. The sun shall not rise, the sun shall not rise. *Aue, Aue!*' Here she fell insensible on the rush floor, and with the sister was carried out." The seance was prolonged far into the night, and soon after the proceedings terminated the whole village was roused by the report of a rifle. "Out I rushed. A house had been set on fire to make a light. Before another house, close at hand, a dense circle of human beings was formed. I pushed my way through, and there, in the verandah of the house, was an old gray-bearded man; he knelt on one knee, and on the other supported the dead body of the young girl who had said she would follow the spirit to spirit-land. The young girl had secretly procured a loaded musket, tied a loop for her foot to the trigger, and blown herself to shatters."

Given, then, a people who are highly emotional, whose brain is in a state of unstable equilibrium, liable to excessive excitement or profound melancholy; who have no fear of death, and in whom the life-preserving instinct is feebly developed; who are deeply superstitious, attributing unlimited evil powers to their malignant gods and wicked sorcerers—when one possessing such mental attributes in a marked degree becomes convinced that he is the victim of a powerful god or *tohunga*, the excessive nervous shock renders the whole nervous system paretic; he offers no resistance to the stuporose condition which then supervenes; he becomes self-absorbed and dwells on the enormity of his sin and the utter hopelessness of his condition; he is the helpless victim of delusional melancholia. He is submerged by one overmastering delusion: he has offended the gods, he must die. There is an abeyance of interest in things external; the morbid state is most acutely centralised; there is great nervous depression; there is a loss of physical energy, and this secondary depression spreads gradually to all the organs: the vital functions are all depressed, the heart becomes depressed, the involuntary muscles become dormant, and finally there is a complete anergia or death. The unbalanced mind succumbs without a struggle to the severe mental shock of overwhelming superstitious fear.

Venereal Diseases, Diarrhœa, etc.

Gonorrhœa was introduced by the early whalers' and traders' crews.

Kotureture is a venereal disease. It causes the skin of body and limbs to turn a hideous white, in large blotches. The natives

believe that this disease is caused by eating the liver of the shark. Copper filings from a penny are used to cure the *kotureture*. Another method of treating this and other venereal diseases, as also piles, is to make a hole or short tunnel in an earth bank, with a small shaft for an outlet. A small smoky fire of chips or shavings of *totara* is made in this tunnel, the smoke escaping by the shaft, over which the person sits, covered with a sheet or old cloak to prevent the smoke from escaping too rapidly.* This disease of the *tara wahine* is thought by my informant to be syphilis, a disease which he thinks is not nearly so prevalent among the natives as it was twenty or thirty years ago.

Goitre, or *tenga*, is common in the high-lying district inhabited by the Tuhoe tribes. Those afflicted by it are mostly women. No attempt seems to be made to cure it. The term *tenga* is also applied to the *pomum Adami*, and to a bird's crop. Elsdon Best has only seen three men affected by goitre in his neighbourhood, but many women there have it, some of them being quite young.

Sneezing (*matihe*) is looked upon as an evil omen, a token of coming disaster or sickness. Several short charms are used to avert the trouble. Some simply repeat the words "*mahihi ora.*"

Delirium in sickness is termed *kutukutu ahi*. It is said to be the aimless talking of the *wairua* or spirit of the sick person, and is considered a fatal sign.

To restore a person apparently drowned the process known as *whakapua* is employed. The person is held so that the smoke of a fire will enter his nostrils, which will revive him (*ka ketu ake te manawa*). The same treatment is adopted in cases where persons have been bitten by the poisonous *katipo* spider (*Latrodectus*). Some state that the sufferer was first placed in a stream.

The bark of the *manuka*-tree is used for diarrhœa and dysentery. Pieces of the bark are boiled until the water is dark-coloured, and this decoction is drunk. Here again superstition steps in. The aged lady who gave me this note states that just twelve pieces of the bark must be used, neither more or less, and they must all be cut of an even length and size. If this be not done, then the medicine will not be effective. The bark of the white *manuka* only is used, the branches of which are drooping and the leaves fragrant, and which is said by the natives to be the male tree—*rakau toa.**

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* Elsdon Best.

Epidemic Diseases (*Papa reti* or *Mate uruta*).

Terrible decimating epidemics have at various times, but particularly during the decade 1844 to 1854, swept through the Maori villages.

In all probability infectious fevers were introduced by Europeans, prior to whose advent epidemics were never experienced or but seldom. "It is undoubtedly a fact that so soon as Europeans arrived in New Zealand the native tribes were afflicted by very serious epidemics, which swept off great numbers of the people. They perished by thousands, many villages being almost depopulated, and many settlements were decimated on account of the scourge. Natives of several parts of the North Island have told me," says Elsdon Best, "that when the famous *rewha-rewha* was ravaging the land the dead were often so numerous that they were left in the houses unburied, while the survivors fled in terror to seek a new home elsewhere. A village known as Te Neinei, near my present camp, was so deserted, the survivors settling at Pa-puweru. Some visitors coming to Te Neinei found the dead lying in the huts, and partially consumed by rats. Epidemics of this nature are termed by the Tuhoe people *papa reti*, the name of a sort of toboggan formerly used by them. The dying of many people was compared with the swift motion of the toboggan down the slide. Or, as an old man explained it to me, 'Tuhoe flowed like water down to Hades.' Pio says that was on the second coming of Captain Cook that these epidemics commenced their ravages, and that they spread all over the island, numbers dying in every village. So many died that for the first time the dead were all buried near the villages. When an epidemic desolated the Rua-tahuna Valley in 1897 I was informed that the cause of the visitation was the fact that the *tapu* had been taken off the sacred house Te Whai-a-te-motu, at Matatua, in order that visitors might be entertained therein. The gods had punished this act of pollution by sending the epidemic among the people.

Epidemics such as influenza and dysentery were undoubtedly introduced by white sailors, and were attributed by the Maori to the displeasure of the foreigner's gods, or in some cases to the gods of the missionaries, who were supposed to be annoyed because the natives did not reject their heathen practices and the worship of the gods of their ancestors. Influenza, dysentery, coughs, certain skin affections, and venereal diseases were thus accounted for.

"The only epidemics I have heard of," says Best, "as prior to the advent of Europeans were those caused by remaining too long on a battlefield, and continued eating of human flesh in a

state of decomposition. When the big party of a thousand Ngapuhi, Rarawa, &c., were camped near Wellington in the early part of last century, some hundreds of them died from this cause. The survivors said that the cause was the taking for fuel of some of the brush or scrub of which their priests' hut was made." It seems clear, however, that these deaths were due to ptomaine poisoning, and, strictly speaking, this is not an instance of epidemic sickness.

Dysentery.

Epidemics of dysentery (*tikuku*, *torere*, *koea*, *tikotiko-toto*) were prevalent among the Maoris in 1795, and in the year 1800. The former epidemic occurred just after the visit of a European ship to Mercury Bay, near Auckland, and proved fatal in very many cases. The natives called the disease *makoko*, or *maripa*. The latter epidemic, which commenced among the natives in the north, was one of the most disastrous of the pestilences which have at different times decimated the Maori tribes. This was the above-mentioned *rewharewha*.

In the treatment of dysentery the Maoris obtained relief by masticating and then swallowing the leaves and tender shoots of the *koromiko* (*Veronica salicifolia*) and the leaf of *kopata* (*Geum urbanus*). A decoction of the leaves of the *tutu* (*Coriaria ruscifolia*) and of the *ti* (*Cordyline australis*) were likewise used, also the tannin-bearing inner bark of the *pohutukawa* (*Metrosideros tomentosa*) and bark of the *kawakawa* (*Macropiper excelsum*), while the gum of the *harakeke* (*Phormium tenax*) served as an excellent demulcent. The administration of these herbs was usually accompanied by the repetition of charms to make them potent, and in cases of diarrhœa the proper *karakia* was called *He korere*. It may be translated thus :—

> Stop up the looseness, allay the flow,
> The purging will subside, the purging is stayed.
> There is purging and there is stopping up,
> For this is the remedy that stayed
> The malady of thy ancestor Houtaiki.

Influenza.

Influenza epidemics also came with the pakeha ships, and the disease was named "the foreign disease" (*rewharewha*, *tarutawhiti*, *taiawa*, or *tarewha*). The precise date of the first epidemic is uncertain; by some it is fixed at 1790, and by others at 1836. In the year 1844 this disease carried off multitudes of Maoris, many dying from exposure to cold while suffering from high fever, and others from jumping into the sea or river to cool their burning skins. "At this period," says Taylor, "the same com-

plaint was raging in all the Australian colonies, as well as in the various settlements of New Zealand." Dieffenbach, writing in 1843, says, "Epidemics of influenza are still common. The disease is a bad form of influenza, a malignant catarrh of the bronchi, with congestion of the lungs, affection of the heart, accompanied by fever and great prostration of strength." At this period, it is interesting to note that immense numbers of dead fish were thrown up on the shores, and in a later epidemic the illness first attacked poultry and pigs and dogs, later causing many deaths in the native villages—which always swarmed with dogs and poultry. Breathlessness and severe headache were two of the most pronounced symptoms of the disease among the Maoris, as with Polynesians generally, and it was commonly called "the head-splitting disease." When influenza was very prevalent in the north, one of the Maori *tohungas* declared that he had found a cure for "the head-splitting disease." It was composed of roots, bark, and leaves of trees, with certain shrubs, burned together, the ashes being mixed into a paste with hogs' lard. This mess he sold to his patients in balls the size of a marble, charging £1 10s. each. They were bought with avidity by timid persons, who, when they felt the least pain in any part of the body, made an incision in that part and rubbed a portion of the compound into it. "It was astonishing," says White, "to see how many cures were affected by it amongst those nervous persons in whose imagination alone the disease had existed."

About the end of the eighteenth century the Kauarapaoa Pa on the Whanganui River was held by about eight hundred natives when the devastating *rewharewha* epidemic broke out among them. An old native thus described it to Mr. Best: "Friend, I will now tell you of the first sign of the white man which came to us. It was the *rewharewha*, the disease that slaughtered the Maori people, until thousands were represented by hundreds, and hundreds by tens. When attacked by that disease, for one night and one day might man look upon the world of life: then death came. Men did not die singly, but in tens, and twenties, and thirties. Day by day and day by day they died. No effort was made by the survivors to mourn for the dead, or to carry out our ancient burial customs, for a great fear was upon them. And the hearts of the living breathed not as they looked upon the multitude of the dead. So the children of Paerangi went down to Hades. Then the survivors fled to the ranges, and a war party which came to attack the fort found only the dead therein, many of whom they ate."

THE MAORI'S AVERSION TO EUROPEAN DOCTORS.

Tohungas, *Ancient and Modern.*

The natives still place great faith in their *tohunga*, and the modern *tohunga* is a kind of quack doctor, a hybrid imposition, a fraud, a despicable fellow, inferior in every way to his savage ancestors, who were, at least, more honest in their professions.

The Attitude of the Maori to European Doctors.

A great distrust of European doctors is manifest in the Tuhoe district. "It is probable," says Best, "that this is not due to any disbelief in the medical knowledge of the said profession, but that the natives have an instinctive fear that a doctor will interfere with their state of *tapu*; that the life-principle will be endangered by the methods of the European being employed. A middle-aged woman of this district was taken seriously ill, and it was proposed that she be sent to the hospital. Her people strongly objected, urging her to adhere to native customs, saying they would rather see her die than be operated upon by a European. However, she was taken to the hospital by Europeans, was operated upon, and recovered. When she returned here I heard an old woman ask her, 'In what state are you now?' (*i.e.*, 'Have you deserted our *ringa tu* religion, are you *noa*?') The reply was, 'O, every cooking-vessel of the white man has been passed over me' (her body had been washed with water heated in a kitchen). Her *tapu* has gone, and she is clinging with great earnestness to European ways and customs, as a means of protecting her vitality. But this is a rare case. There is another singular idea possessed of the native mind. A native is ill, and you ask why he is not taken to the doctor. The reply will very likely be, 'Oh, it is a native complaint; the doctors could not cure it,' although it be something as common as stomach-ache."

When travelling in the Taranaki District many years ago Sir George Grey found the natives very willing to take European medicine. They fancied that every *pakeha* was by nature a doctor, and never travelled without a medicine-chest, from which their sick expected remedies almost as a matter of course. Those whose maladies were relieved were seldom grateful for it, whilst those who were not benefited went away grumbling, as if they had been seriously injured. In Fiji the natives are even more ungrateful, and in one instance a native asked the European doctor for payment for the time expended in having his sores dressed by the medical man without expectation of fee or reward, and also demanded a shilling for attending to the dressings himself when the doctor was necessarily absent.

Again, the Maori dreads visiting the white medicine-man for fear that some surgical operation or amputation be suggested. For instance, once a native had his arm badly crushed. He was taken to the nearest hospital, but would not hear of having the limb amputated without his father's consent, and the old fellow flew into a fearful rage when he was consulted, saying his son would want his arm in the next world, and it was better for him to die with it and keep it, as it could not be sent after him. The Fijians also believe that in the future state they retain the precise physical attributes pertaining to them at their death. If they die minus a leg or arm, then in the next world they remain for ever deformed. This belief has led to some curious incidents. For instance, a young Fijian who was sick and unable to eat was buried alive, because, as he himself said, if he could not eat he should get thin and weak, and the girls would call him a skeleton and laugh at him, while in the other world he would for ever be subject to the jeers and taunts of his comrades. He was buried by his own father; and when he asked to be strangled first he was reprimanded and told to be quiet and be buried like other people. It was the same pride of physical appearance which made Maoris dread anything of the nature of surgical mutilation, however necessary such interference was for their well-being, or even for the preservation of life.

Menstruation.

The Maori terms for menstruation are *paheke* and *mate marama*. The former term is used also as a verb (*cf. heke*, to drip); the latter literally means "monthly sickness" (*marama*, the moon, the lunar month). The term *atua* is also sometimes applied to the menses. This word, which generally signifies "god," or more correctly "ancestral spirit," is also given to various obscure phenomena, as, for instance, menstruation.

Regarding lunar influences on women, native authorities informed Mr. Best that "the reason of this sickness being known as *mate marama* is because it affects women when the moon appears. It never affects them when the moon is lost to view—that is, during the dark nights (*hinapouri*) of the moon. Some women are affected when the moon is first seen, and others at various stages of its growth; some when the Turu moon appears (*i.e.*, the seventeenth night of the moon). A woman is always affected at the same stage of each moon; the time of her *paheke* does not vary." Another native, an old woman, said, "Women do not *paheke* during the dark nights of the moon, nor yet while suckling a child, although the child may suckle its mother for a long time." When the moon appears, the skin of women who have chronic dysmenorrhœa becomes rough, like what we term

" goose-skin." When the moon appears, then women say, " The husband of all women in the world has appeared." Another native, an old man, said, " The moon is the permanent husband of all women, because women *paheke* when the moon appears. According to the knowledge of our ancestors and elders, the marriage of man and wife is a matter of no moment: the moon is the real husband."

There was, and still is, a certain amount of *tapu* placed on a menstruating woman. The discharge is viewed as a sort of human embryo,* an immature or undeveloped human being: hence the *tapu*. An aged native said, " The *paheke* is a kind of human being, because if the discharge ceases, then it grows into a person: that is, when the *paheke* ceases to come away, then it assumes human form, and grows into a man."

A chief or man of rank avoids the sleeping-places of women, because contact with clothing or places polluted by the *paheke* would render him *kahupotia*, or devoid of the clairvoyant power. In this state he would no longer be able to observe the numerous signs by which ancestral ghosts warn their living descendants of impending troubles and dangers. " Son," said an old Ngatiawa *tohunga* to Mr. Best, " never recline on the resting-places of women. Such places are unclean. The blood [*i.e.*, *paheke*] of woman is there. They are the undoing of man. But should you happen to do so, then be sure that you conciliate your ancestors, that they may restore your sight, and continue to guard and preserve you from evil." A man would perform the *whakaepa* rite in order to free himself from the polluting effects of the *moenga toto*, or unclean sleeping-place.

Australian blacks have a similar dread of pollution from contact with menstruating women. Those of the Leichhardt River, for instance, would immediately kill a woman who thus contaminated them. In their gesture language they had a special sign or signal for menstruation, so as to enable women to warn men of their condition, from a distance. It is stated that a blackfellow (N.S.W.) once slept in a blanket that had been used by his *gin* (wife). When he came to know that it was defiled, he thrust his wife through with a spear, and shortly afterwards he himself died from fear of the consequences of the pollution.

" If a menstruating Maori woman goes on to a sea-beach where *pipi* shellfish are found, all those shellfish will desert that beach and migrate to pastures new. Or if such a woman essays to cook the kernels of *tawa*-berries in a boiling spring, they will never be cooked, but remain quite hard, although those of other women, not in that condition, will be quite cooked. They believe also that if a menstruating woman goes to an *ahi titi* (a fire made

* See *Kahukahu*.

to attract the *titi*, or mutton-birds, and at which they were formerly taken in great numbers), no birds will be caught. For the birds will persistently avoid the fire, and will be heard crying out and screeching. Then the fowlers will know that a menstruating woman is among them. They will know it from the actions and cries of the birds."

"The term *paheke* has, strictly speaking, three applications. It is the name of the discharge, it is the verb 'to menstruate,' and it is also applied to the day of the menstrual onset. The term *koero* is given to the second and third days of the period. When a woman does not desire to conceive, she will not cohabit with her husband during menstruation, or rather during the *koero-tanga* (*koero* stage), for such connection, she believes, would certainly result in pregnancy. She therefore abstains until three days after the period has ceased. Thus, according to Maori ideas, it is during the *koero* stage that the sexual act is most generally fruitful."

"The material used among the Tuhoe natives, from time immemorial, as a menstruating diaper is a variety of moss (generic term *rimurimu*) known as *kohukohu* or *angiangi*. It is probably *Hypnum clandestinus*. It is a light-coloured, fine, very soft moss, found growing on logs in the forest. As used for the above purpose it is termed a *kope*. It is not prepared in any way, but simply crumpled up and thrust into the vagina. After the discharge has ceased, the woman goes into the forest and buries the *kope*, each woman having a secret place where she does so. It would be a serious matter for her were her *kope* to be seen by any one. For they would probably make a great joke of it, and she would feel terribly humiliated—so much so, indeed, that she might commit suicide."*

When an Australian aboriginal girl reaches the age of puberty she is subjected to very great cruelty, and undergoes in certain tribes most painful surgical operations. In the Arunta and Ilpirra Tribes of Central Australia she has to sit over a hole dug in the ground for two days without stirring away; in Victoria, cords are tied tightly around several parts of her body, causing great pain and swelling; but the most repulsive procedure is the horrible operation of *atna-arilha-kuma* (*atna*, vulva; *kuma*, to cut), performed soon after the onset of menstruation. In this initiatory or marriage rite the hymen and perineum are rudely lacerated with a wooden instrument, or stone knife. Such barbarities seem never to have been practised by the Maoris, nor indeed in any part of Polynesia, except perhaps on rare occasions, and with much less severity, in Fiji and Samoa. In New Zealand

* All the original matter in this paper pertaining to menstruation, pregnancy, parturition, &c., has been collected from the Tuhoe Tribe.—E. B.

no special attention seems to have been paid to the young woman at this time—she underwent no ceremony of initiation, and was not in any way tortured or operated on like her less fortunate Australian sister.

Like the Parsee woman, the Maori *wahine* is possessed by a demon during menstruation—or, rather, she becomes dispossessed of a malignant disease-dealing demon, the *atuakahu* previously referred to. The Hebrew woman was *tapu* (unclean) during the monthly period, and, like the Maori, "everything on which she sat or lay during this time, and every one who touched such things or her, incurred uncleanness."

Thomson found that the Maori girls commenced to menstruate at thirteen, fourteen, fifteen, or sixteen. He heard it stated that they commenced at ten years of age, but he disbelieved it. Moriori women reached puberty at from thirteen to sixteen years, about the same as the Maoris. "Among the Maoris," says Batty Tuke, "the menstrual discharge appears at regular intervals within six weeks after childbirth." The child-bearing period is said to extend from sixteen to thirty-five years of age, but Thomson knew of a native whose age must have been forty-seven when she gave birth to a child.

Every respectable Hawaiian family had a series of houses forming its establishment, including one named the *hale-pea*, the house of separation for the wife during the period of her infirmity. No such houses were found in Maori communities, nor did the menstruating woman paint her head and body with a mixture of red clay, as did the natives in New South Wales, nor with turmeric and oil, as did the women in various parts of Polynesia.

Thomson has noted menorrhagia and metrorrhagia among the Maoris, and says that sometimes menstruation is very irregular with them. He is of opinion that they are subject to the same irregularities as women in England; but these irregularities are perhaps not so common, nor do they appear to have so much influence on the constitution. Bennett* observed several deaths among the Maoris from *niu toto* (uterine hæmorrhage).

In cases of difficult menstruation a decoction made from flax-root (*Phormium tenax*) and a creeper called *aka taramoa* (*Rubus australis*) is used. Another medicine is made from the bark and berries of the *rohutu*-tree (*Myrtus obcordata*). Women suffering from dysmenorrhœa were usually isolated in former times. In native opinion it is the moon that is affecting a woman when thus suffering. The natives of the Tuhoe Tribe state that their women have more trouble during menstruation of late years

* Lond. Med. Gazette, ix., 1832, p. 436.

than they had formerly. With this increasing tendency to dysmenorrhœa there is an increasing lack of fecundity.

Pathological amenorrhœa, which is not very common among the Maoris, though perhaps more frequent among the half-breeds, is spoken of as *he mate kino na te marama* (an evil complaint caused by the moon). Such an illness may continue for a week, during which time the woman will take but little food. At such a time women have a great desire to drink cold water, but are not allowed to take much lest it should aggravate the trouble.

Amenorrhœa is termed *papuni*. To cure this a woman will, at dawn of day, go and bathe in a stream, and then on her return she takes a decoction made as follows: Four pieces of flax-root (*Phormium tenax*), and four pieces of the branchlets of a forest-climbing plant known as *aka taramoa* (*Rubus australis*), are cut up into small pieces and boiled in a vessel until the liquid is considerably reduced in quantity. When obtaining these roots and twigs they must be taken from the east side of the flax-clump and creeper, as the *mana*, or virtue, of them is on that side only, as regards their use as medicine for menstruating women. This singular superstition may be connected with the rising of the moon in the east, for when the same materials are being procured for the purpose of making a medicine for diarrhœa, or constipation, it does not matter from which side they are taken.

Vicarious menstruation has been observed among the Ruatahuna natives. A woman of the Hamua clan has a discharge of blood from the nose at each appearance (*kohiti-tanga*) of the new moon. This is termed her menses by the natives, inasmuch as the ordinary discharge is invariably absent.

Pregnancy (Haputanga).

The Maoris have several theories to explain the process of conception. By some tribes the pregnant state is attributed to the moon-god, who is, as we have already pointed out, "the true husband of all women." Others believe that during sexual intercourse the male transmits to the female the life-principles (*hau* and *wairua*) of the fœtus, the woman being merely the receptacle in which this germ matures. In other cases women are supposed to become *enceinte* owing to the supernatural influences of certain conception stones, phallic trees, incantations, and magic dolls. Certain Australian tribes (Arunta, Luritcha, and Ilpirra) firmly believe that the child is not the direct result of intercourse, and that at pregnancy the woman becomes "possessed" by an already formed spirit-child, the natural habitations of which are certain gaps in the ranges, and the vicinity of phallic monoliths, such as the Erathilpa Stone, near Alice Springs (C.A.). Maori beliefs are very similar to these. They say the soul or

spirit is created by the gods in the seventh heaven, called *autoia* (" here the spirits of mortals begin to live "), coming to earth. These spirit-children render women pregnant, and thus assume a material body, or become malignant demons (*kahukahu*) in the manner described elsewhere.

Another extraordinary explanation of the physiology of impregnation is the following, given to Mr. Best by an aged Tuhoe *wahine*: " There is," she said, " a certain substance or organ in woman. This is white outside and reddish-yellow inside. It resembles a bird's egg. A row of these extend from the base of the liver (*ate*) to the womb. When the husband has connection with his wife a portion of the white substance attracts the semen of the male, and these two substances unite, the male's and the female's, and also a portion of the blood of the *paheke* (menses), and become one and are enfolded in a part of the white substance, and then develop into a child." This is probably a Maori perversion of a European story; it is altogether unlikely that such a theory should originate in the native mind.

Phallic Stones.—Sterile Maori women, like Australian aboriginals, Banks Island and Fijian women, were acquainted with phallic or conception stones. One well-known stone of this kind stands on the bank of the Awaroa River, in the Kawhia district, and married women who have had no children perform ceremonies and chant incantations to the *atua* of this stone that they may become mothers and have children to nurse. Their tradition is that the god Uenukutuwhatu (Rainbow with hailstones) turned himself into a *taniwha* (water-demon), and then became the above-mentioned stone. In Fiji there are similar stones which the women worship. These monoliths represent the generative principle and procreation, and in many ways resemble in form, and in the mode they are worshipped, the phallus of the Phœnicians, and the similar gods whose worship assumed such offensive forms in ancient Rome, and found vent in the noblest monuments of the Pharaohs.

Phallic Trees.—Mr. Elsdon Best* has recorded some extremely interesting facts concerning certain so-called phallic trees existing in various parts of the North Island of New Zealand. These trees are supposed to have the power of rendering sterile women fruitful. The potency of the conception stone above referred to was apparently attributed to the indwelling god Uenukutuwhatu, but the special functions of these phallic trees were derived from a totally different and unique source. According to Maori cosmogonic myth man and plants are the offspring, by different wives, of the god Tane-nui-a-rangi. The

* " Te Iho-o-kataka," *Auckland Weekly News*, 20th Sept., 18[illegible]

birth of the various forest-trees preceded that of the first human being; but trees did not give birth to men, as in the myths of the Hereros, Kaffirs, West Africans, &c. The Ovahereo or Damaras trace their origin to a sacred tree from which were also begotten the Bushmen, oxen, zebras, and all other living things. The Maori recognised, as did the Buddhists, Karens, Ojibways, and other primitive peoples, that trees had what may be called souls, and also that ancestral ghosts, and the souls of gods and demons, might be confined in or take up their abode in trees. In India the doctrine of transmigration "widely and clearly recognises the idea of trees and smaller plants being animated by human souls." "All over the world, from ancient Egypt to the wigwams of the Algonkins," says Andrew Lang, "plants are said to have sprung from a dismembered god or hero, while men are said to have sprung from plants." In Bengal we find the curious custom in certain totem clans of marrying the bride and bridegroom to trees before they are married to each other. The bride touches with red lead a mahwa-tree, clasps it in her arms, and is tied to it. The bridegroom goes through a like ceremony with the mango-tree. This is done possibly with the idea of rendering the union of the couple fruitful, but we have no definite information supporting this theory. The Yarucaris of Bolivia say that a girl once bewailed her loverless estate. She happened to notice a beautiful tree, which she adorned with ornaments as well as she might. The tree assumed the shape of a handsome young man—

> She did not find him so remiss,
> But, lightly issuing through,
> He did repay her kiss for kiss,
> With usury thereto.*

The special virtues of the Maori conception trees did not depend on any peculiarity of their growth or species; nor was it attributed to the presence of any god, demon, or ancestral ghost who may have taken up his abode in the tree; nor was the tree regarded as a man or god who had assumed the outward form of a denizen of the forest. Mr. Best regards these trees as phallic symbols, and "evidences that the ancestors of the Maori practised the phallic cult." That the Maoris in olden times did practise phallic worship cannot be disputed, but there is but little to support the theory that their conception trees were phallic symbols.

The conception trees are thus described by Mr. Best: "The Iho-o-kataka is the name of a famous *hinau*-tree which stands in the Upper Whakatane Valley, in the land of the Urewera

* J. G. Müller: quoted by A. Lang, "Myth, Ritual, and Religion," vol. i., p. 155.

Tribe. It holds an important place in the annals of Tuhoeland, inasmuch as it possesses the singular power of rendering barren women fruitful. It came about in this wise: When Kataka, the daughter of Tane-atua, was born in Hawaiki, some seventeen generations ago, Irakewa took the *iho* (umbilical cord) of the child and came to Aotearoa (New Zealand) on a *taniwha* (sea-monster), and placed the *iho* on a *hinau*-tree near Ohaua. Later on Tane-atua arrived in the Matatua canoe and landed at Whakatane, in the Bay of Plenty. And it chanced that when Tane-atua, while travelling in the interior, sat him down to rest beneath that tree and stretched forth his hand to pluck some berries therefrom, what was his surprise to hear a voice say, "Do not eat me, for I am the *iho* of Kataka, your child." Upon hearing the voice Tane-atua refrained from eating the fruit of the *hinau*, and he then took the *iho* of another of his children and inserted it at the base of the tree (or suspended it on the tree), at the same time repeating this incantation:—

Ko whakairihia ahau
Ko whakato tamariki ahau.

("I am here suspended that I may cause children to be conceived.") This is how this tree became possessed of the power of causing children to be born into the world. And the name of that tree has ever since been Te Iho-o-kataka, and the *iho* of our children have always been hung up in the same tree, even unto the days of the *pakeha* (white man). And before being hung up the *iho* is wrapped up in *aute* or *raukawa* (the paper-mulberry and *Panax edgerleyi*, a scented shrub), and bound round with *aka* (a climbing plant).

When a woman is *pukupa* (barren) she goes to the *hinau*-tree and embraces it. But great care must be taken to comply with the due ceremonies, so she is accompanied by a priest, who during the performance repeats the necessary incantations. If she embraces the *taha tane*, or male side, that towards the rising sun, the issue will be a male; and a daughter is produced by embracing the female side (*taha wahine*), that facing the setting sun. The sex of the child is determined by the side embraced by the would-be mother.

The *tohunga* or medicine-man who revealed these secrets thus concluded his narrative: "Friend," said he, "there are two men, Pahi and Ramarahi, now living at Rotorua, who were born through the influence of this tree."

"Te Hunahuna-a-po is the name of another phallic tree, which stands close to the Horomanga Creek, some six miles from Galatea. According to the Ngatimanawa account this tree is also a *hinau*, and has one dry side and one green. Should a *wahine pukupa* go to this tree to test its virtues, she closes her

eyes afar off, and approaches in that manner. She is very careful as to the manner in which she draws near to the talismanic *hinau*. '*Kia kaua e haere Maori noa iho.*' She embraces the tree for a considerable time, and then, with her eyes still closed. she turns her back to the tree, that she may not see the part she has embraced. But it is not unknown to the priest who is watching her as to which side she has clasped. If she embraces the living side of the tree, then will she surely bear a child; but if the dry or dead side, no child will come to gladden her. There is a person living at Galatea who was born through the power (*mana*) of this tree, and his name is Te Ai-ra-te-hinau."

Te Puta-tieke, a *pukatea*-tree near Opotiki, is also endowed with the same virtue.

The Maoris compare the placenta (*ewe*, *whenua*, *puwhenua*) to the earth, "the land of one's birth," "exhausted land," from which springs *uho* or *iho*, the umbilical cord, which appears to have been compared to the trunk of a tree (?) (cf. *uho*, the heart-wood of a tree, the stem or kernel of fruit; *tara-uho*, the heart of a tree; *iho*, the heart of a tree, that wherein the strength of a thing consists), or to the long, fibrous root of a tree or shrub (cf. *tangaengae*, the navel-string; the middle part of the fibrous root *aka*). *Tangaengae* (myth) is a spirit standing at almost the lowest point of creation and helping to sustain the universe, the child being the fruit of the tree. At birth the placenta is carefully destroyed by burning, burial, or being thrown into the river or sea. This is done to prevent hostile sorcerers securing it and using it as a "bait" with which to kill or make sick the mother or child by sympathetic magic. The *iho* was also sometimes buried in a sacred place, and over it was planted a young sapling, either a *ngaio* (*Myoporum lætum*), *karaka* (*Corynocarpus lævigata*), or *kahikatea* tree (*Podocarpus dacrydioides*), which, as it grew, was *he tohu oranga* (a sign of life) for the child.* The umbilical cord of a chief's son was often placed under a stone or on a tree at the boundary of the tribal lands to maintain and strengthen the tribal influence over such a boundary. The *iho* of children of many succeeding generations might be placed in the same spot. The *iho* was sometimes placed in a tree, and that place would ever after be known as "the *iho* of So-and-so." At Te Ariki is a tree in which the *iho* of a priest's child was placed, and the hole closed with a piece of precious greenstone. The latter addition enhanced the *mana* of the *iho*.†

Thus it is clear that the *iho*, or umbilical cord, was regarded by the Maori as being a structure of very great importance, being

* "Te Ika a Maui," Taylor, p. 74.

† "Notes on some Customs and Superstitions of the Maori," Best. Trans. Austr. Assoc. Adv. Sci., 1898.

severed at birth with much ceremony and priestly incantation, and afterwards carefully deposited in some special spot or common tribal repository. The *iho* was apparently supposed to retain part of the vital essence of the child from which it was taken, and this would influence the growth of a tree planted over it, or endue the object or place of its lodgment with mystic powers (*mana*). The tree Te Iho-o-kataka clearly gained its supernatural power from the *iho* of Kataka, the daughter of Taneatua, but it is not clear how the *iho* was regarded in this case. Possibly the umbilical cord attracted child-spirits desirous of becoming embodied in the fruit of the root or stem (*iho*) on which children grow. If so, naturally trees in which the *iho* of all the children of the tribe were hung would swarm with the unborn souls of children waiting for a suitable opportunity to render a woman pregnant, and thus pass from a spirit to a material sphere of existence.*

There seems to be no ground for regarding these conception trees as phallic symbols. For we have already pointed out that the Maori did not generally attribute conception to sexual intercourse,(?) but to supernatural influences. Te Iho-o-kataka gained *mana* from the *iho* of a female child, and it is owing to some obscure supernatural attributes of the *iho*, and not of the *ure* or *tawhito*, that this tree can make barren women conceive.(?)

"Another method of rendering barren women fruitful is by means of the magic rite called *whakato tamariki* (*whaka*, a causative prefix; *to*, pregnant).† The efficacy of this strange sorcery is still believed in by many of the natives still living. The sterility is overcome by the supernatural power of the all-powerful priest-physician, who would give his patient directions how to act First she must obtain a handful of the fragrant grass termed *karetu* (*Hierochloe redolens*), and insert therein a portion of *paraheka* or *tatea* (semen and preputial secretion). This she hands to the *tohunga*, who takes it to the *wai karakia* or sacred pool of the village. There he performs his peculiar rite, singing over the bunch of grass the following *karakia* to cause the woman's sterility to leave her and to make her conceive :—

Ka whakato au i a koe ki a papa-tuanuku
Kia puta mai a papa-tuarangi
Kia niwha i roto i a koe
Kia puta mai i roto i a koe
Ko wairua whai ao
Ko wairua tangata
Ko Tu-kaniwha, ko Tu-ka-riri
Ko Tu whai ao

* This is not the native idea.—E. B.
† This item is from the Tuhoe Tribe.—E. B.

Ko Rongo-matane
Kia puta i roto ko Tu-mata-uenga
Kia mau ki te rakau
To rakau poto, to rakau roa
I puta ana mai
Ko Wahieroa na Tawhaki
Ka horohoroa i unga
Ka horohoroa i raro
Ka puta ana ki waho ko Te Hapu-oneone
Ka whanau i roto i a te hapu
Na Tiki-nui, no Tiki-roa, na Tiki-apoa
Na Tiki-tahito, na Tiki-hou
Ka pa ki te ruahine
I a kahau ki waho
I a kahau ki uta
I a kahau matire rau.

" The above is the form of *karakia* used should a male child be desired. If a female child is wanted, then, instead of the name Rongo-ma-tane, that of Rongo-mai-wahine is inserted, and the lines following it are altered so as to apply to a female, whose labours were dedicated to Hine-te-waiwa—that is, to weaving and the various domestic duties. Male children were dedicated to the service of Tu, the god of war.

" When the marriage feast, known as the *kai kotore*,* was held, the priest recited over the young couple an invocation called *ohaoha*, in order to preserve their physical and spiritual welfare, as also to cause the woman to be fruitful. It often happened that the bride's sisters would decline to eat of the food of the particular oven termed the *umu kotore*, which was prepared for such relatives only, lest they should become sterile (*koi purua*)."

A sterile Maori woman sometimes made a *whaka-pakoko-whare* or small house,(?) adorned it with the family treasures, treated it with great reverence, and saluted it with endearing terms. This image, often a mere doll, she nursed in the hopes of becoming fruitful. They also, it is said, repeated special incantations, called *uruuruawa*, for the cure of barrenness. The Tuhoe natives called the images above referred to *whaka-pakoko*, a word meaning " image." This image was in human form, and usually made of wood. In some cases a stone was so dressed and carried by the childless woman, and even potatoes were sometimes so utilised. Mr. Best knew a woman who, being barrén, used to nurse a young pig in her arms, as a substitute. Wherever she went the little pig accompanied her, sometimes carried in her arms, at others it would be seen trotting along behind her. Fashionable women in Paris and New York similarly carry puppies and monkeys. It has been stated that the *whaka-pakoko* were regarded as gods, and also that they were carried

* See Trans. N.Z. Inst., vol. xxxvi.

in order to cause the bearers to conceive. The Tuhoe natives, however, seem to have nursed them merely as the result of the unsatisfied maternal instinct. Women who nursed and petted these singular objects were wont to compose and sing songs (*oriori*) or lullabies over them. precisely as they did to children

Whare ngaro is an expression implying the death of all the children of a couple, leaving them without offspring. This affliction of a *whare ngaro*, or lost house, is said to be caused by the evil influence of ancestral spirits, or is attributed to *makutu* (sorcery). When parents lost by death their first child they would go to the *tohunga* and have the *tu ora* (or *kawa ora*) rite performed over their second child, in order that the threatened *whare ngaro* might be averted and the child survive.

Maori women attribute sterility to the habitual use of fermented food, in the form of maize which has been steeped in water until putrid. This is purely a native idea, and one which they consider is confirmed by the fact that fewer fertile women are found among tribes where this food is a favourite article of diet. Consanguineous marriages are also productive of sterility, and Dr. Batty Tuke many years ago visited a *pa* (fortified village) on the Wanganui River, named Marakowhai, where out of a population of two hundred inhabitants only two fertile females were to be found. That sterility is frequently the result of consanguinity may be deduced from the fact that in many cases where childless women have subsequently formed connections with Europeans, large and healthy families have resulted. Prior to the advent of the whites, early and excessive venery was an important etiological factor, and after the arrival of the whaling fleets was added the potent influence of venereal diseases.

In 1845 Count Strzelecki* expressed the opinion " that when an aboriginal (Australian) female had had a child to a European, she lost her power of conception by a male of her own race, but could produce children by a white man." Dr. Sarsfield Cassidy,† in a paper read before the members of the New South Wales Medical Council in 1898, supports Count Strzelecki's assertion, and declared that " it had been proved, by overwhelming evidence, that a healthy aboriginal male and female cannot beget children should the female have lived with, and borne children to, a white man." Strzelecki's statement was generally believed years ago, and a recent medical work‡ states that the Count " believed this to be the case with many aboriginal races ; but it has been disputed, or at all events proved to be by no means a universal law, in every case except that of the aborigines of Australia and

* " Physical History of New South Wales."
† Journ. Trop. Med., vol. i., p. 141.
‡ " Anomalies and Curiosities of Medicine," Gould and Pyle, p. 89.

New Zealand." Thomson,* however, knew several instances of Maori women having children with men of their own race after having had children by Europeans. And Professor Stirling† and Mr. Taplin have abundantly proved that Australian native women may have a large family of black children after having had one or more half-caste children. Thus it may be justly concluded that this idea is now entirely exploded, and the reverse a matter of notoriety.

The Maoris. whose whole life was so much influenced by omens, had several concerning pregnancy. For instance, if a newly married man, while sleeping sound at night, beholds lying on the ground human skulls ornamented with feathers, he awakes with the assurance that his wife will soon conceive. If the feathers are those of the *huia* bird, it is a sign that the child will be a girl; if those of the *kotuku* (a white crane), the dream prognosticates a male child.

The Australian woman when pregnant must not eat kangaroo, or eels, or birds. Melanesian women are afraid to eat double bananas when pregnant lest they should give birth to twins. Maori women, however, have all their longings and fancies gratified, in as far as food is concerned, during pregnancy; if she desires eels, or wild-turnips, or shell-fish, or what not, her whim is gratified, but not from any idea, such as prevails in Europe, that non-gratification of such would result in some evil or deformity to the child.

The pregnant Maori woman did not, like her Fijian sister, habitually take medicine during pregnancy to prevent irregularities during labour, or to facilitate the birth of the child; nor was she massaged for some months, as was the Tokelau woman, prior to the commencement of labour. *Kava*, and a special medicine called *wai-ni-lutu-vata*, or medicine for simultaneous birth, were taken in Fiji, and the woman was subjected to a curious manipulation, a form of *vakasilima*, to insure a rapid labour. The Maori had no knowledge of such methods of treating or preventing morbid parturition: if Nature failed her she had little to fall back on beyond the incantations of the *tohunga*. The only medicine they knew of for facilitating labour, and this was only occasionally used, was the *nikau* (*Areca sapida*). The pith of this palm was cooked and eaten for a few weeks by expectant mothers, it having the property of slightly relaxing the bowels, and is reputed to relax the pelvic ligaments.

"In former times, when a woman was *rapou* (pregnant for the first time), she sometimes lived apart from others, but not in all cases. Still, she would be under certain restrictions and rules

* Brit. and For. Med.-Chir. Rev., vol. xv., p. 524.
† Rept. Hom. Exped. Cent. Austr., vol. iv., p. 129.

during such period. For instance, she was not allowed to have her hair cut, lest the child be *rehe* (*rehe* = *korehe* = *pukiki* = stunted). She might take a dislike to certain foods, or, as the Maori puts it, the child might be afraid of certain foods, and hence the pregnant woman would also take a dislike to such foods, and decline to partake of them. On the other hand, she might desire, or yearn (*kumāmā*) for certain foods, which would probably be procured for her." (Tuhoe.)

"If she should desire birds, and these are procured for her, and she eats of the wings, neck, &c., only, it is known that the child she bears is a male. But if she eats the body of the bird, then, it is said, the child is a female. A red or flushed face in a pregnant woman also denotes that the child she bears is a female. If a pregnant woman nurses the child of another woman and the child within her moves, she knows that her own child is of the opposite sex to the child she is nursing. If a *whe* (the mantis insect) is seen upon a woman it is a sign that she has conceived, and, according to which kind of *whe* it is, people know whether the child is male or female."

"If a woman desires to bear a male child, having possibly already borne several female children, she will make it her business to be near when a birth takes place in the neighbourhood. If the child, when born, is a male, she will obtain the *whenua*, or placenta, and proceed to *piki* it—that is, she will stand over it for a while, with a foot on either side of it. This singular act, termed *piki whenua*, is also had recourse to by barren women." (Tuhoe.)

"Sometimes, though rarely, a ceremony was performed, and *karakia* repeated over a woman, in order to render her sterile, that she might cease to bear children. Paora Horomata, a Tuhoe *tohunga*, was a famous adept at this rite, known as *whakapa*, but the *karakia* used by him was not ancient, being a part of the ritual of Hauhauism of modern times. His method is said to have been effective. Women who were tired of bearing children and wished to have no more would go to him when near lying-in, so that they might give birth to the child at or near his home. He would be summoned at the birth of the child, and would take some of the blood lost during the separation of the placenta; this blood he would throw into a small fire he himself kindled, repeating at the same time his *karakia*. By this means his patient was prevented from any further conception. He used no medicines in his method." (Tuhoe.)

CHILDBIRTH.

It has frequently been recorded that parturition among primitive and uncivilised races is easier and more rapid than in

civilised countries. This rule holds good for the Maoris, with whom labour is soon over, and the mother almost immediately returns to her usual duties. According to one authority, labour seldom exceeds two hours; generally it is much shorter. After delivery, the woman proceeds to a stream and washes herself and her infant, and then returns home. A Maori woman, the bearer of a burden, with a party of travellers, was confined on the road; after the birth of the child she walked four miles, and next day fifteen. They rise almost immediately after the expulsion of the placenta. Sickness after parturition is rare. Many missionaries and medical men who have lived long among the natives have never heard of a Maori woman dying in childbed. A native chief, aged about fifty, told Dr. Thomson that out of a tribe numbering four thousand souls he could only recollect ten instances of women dying in childbed. This is about one death in three years out of two thousand women. The circumstances which caused death, the chief said, were hæmorrhage and cross-birth.

In some Maori tribes, as soon as the woman finds her labour has commenced, she takes her rug and goes into the open air, into a quiet, retired place. If it is her first child a woman attends her; after the first child she goes alone, no one interfering unless assistance is solicited. In New Zealand, as also in many parts of Polynesia, the woman is often confined in some special house, often enough a very primitive and specially built structure, apart from the village or other houses. This *whare* the Maoris called the fœtus-house, or *whare kahu*, and it was held so very sacred that slaves and persons low in rank dare not come near it. The day after the child was born the mother and child were removed to the *whare kohanga*, or nest-house. Such a ceremony was, of course, restricted to the chiefs' wives. (Tuhoe.)

"When, after parturition, the woman was removed to the *whare kohanga*, her relatives and friends might visit her, so soon as the *tapu* was removed from mother and child. This *whare kohanga*, or nest-house, was not a rude shed, such as the fœtus-house, but a better-built and comfortable place." (Tuhoe.)

"A woman would probably be in the fœtus-house but a night or two before parturition, and would then be removed to the nest-house, together with her child. She would proceed to the *whare kahu* when she knew her time to be near—perhaps when the labour-pains began, or before. She might be one night in the fœtus-house, or longer, especially in cases of protracted parturition (*whakatina*)." (Tuhoe.)

"The caretaker appointed to look after the woman and take food to her while in the fœtus-house is also *tapu*. She must remain with her charge during the time she is *tapu*, and may not

leave the place, nor visit the village, nor approach any place where food is cooked, nor even come near any person who is *noa* (void of *tapu*). When food is prepared for the lying-in woman, it is carried by a *noa* person from the cooking-place, and deposited on the ground at some distance from the sacred precincts of the fœtus-house, the bearer returning at once. Not until that bearer has retired does the *kai tiaki* (caretaker) venture to fetch it. She will get it and carry it to within some little distance of the *whare kahu*, and there deposit the same. The woman will then leave the shed and come to the place where the food is, and there eat it. But the food must on no account be taken near the shed or the child, for it is cooked food, the most polluting and degrading thing known to the Maori — dangerous to life and disastrous to man's future welfare. Should that cooked food be taken near the child while the latter is in the state of intense *tapu* which obtains prior to the performance of the *tua* rite, then the hapless infant would be *tamaoatia*, or polluted; that is to say, the sacred life-principle would be so polluted, and endangered, and the child's welfare probably be utterly ruined. For it would be exposed to all the ills which assail man; it would be lacking in spiritual, vital, and intellectual power and prestige, open to the shafts of magic, the sport of the gods, the food of Hades."

"The term *whare kahu*, or *whare whakahaku*, is to a certain extent a figure of speech, inasmuch as, in fine weather, no shed at all may be erected, the woman giving birth to her child in the open. Nevertheless the term would still be applied to the place, and the same intense *tapu* prevail." (Tuhoe.)

"Even now women are not allowed to give birth to a child in a dwelling-house in a village, but go to a hut, or erect a tent, away from the village. It is deemed unseemly to utilise a dwelling-house for this purpose, and not right that people should hear the groans of the parturient woman." (Tuhoe.)

The Maoris had a famous mat called Takapau-whara-nui,* made from the scalps of fallen enemies. On this the great priests and *ariki* were begotten. Often some dry grass was used by the common people.

The posture assumed by the parturient Maori woman was that invented by the god Tura, or Grey-head. When his wife was about to be delivered he fixed two posts (*turuturu*) for her use. One, called Pou-tama-wahine (the post of the daughter),

* *Takapau-wharanui* is essentially a figurative expression, and is used to denote that a child was born in lawful wedlock. It implies that a special *takapau*, or sleeping-mat, was used during copulation. (*I aitia a mea tanyata ki runga i te takapau-wharanui.*) It is more than doubtful whether any scalp mats were ever made by the Maori. They were not scalpers, but beheaders.—E. B.

he stuck securely in the ground in front of her; the other, called Pou-tama-tane (prop of the son), he fixed at the back of his wife. "Now," said Wai-rangi, "the post or prop at your back is for you to rest against, and the prop in front of you is for you to hold on by, so that you may not be overcome." According to another version of this myth, the god "fixed three posts, so that against one the feet could be pressed, and that the other two could each be grasped by either hand." This mode so delighted the people that it has continued to be practised until the present time.* Sometimes the woman merely kneels down, with the thighs apart, and with the hands resting on a tree or branch; or she may kneel down with the body bent forward and her weight supported by two poles driven into the ground. The kneeling parturient woman is sometimes supported by another woman kneeling behind her and grasping her round the body; or the assisting *sage-femme* may place herself in front of her patient, and, while kneeling on one knee, use the other to massage, or press firmly over, the lower part of abdomen or uterus of the woman in labour. Sometimes, if there is any delay in the labour, the parturient woman twines her arms around the knees of an assistant in order to press them against the fundus of the womb. In cases of protracted labour violent pressure is applied to the abdomen, and Dr. Thomson saw a young Maori woman who was suffering from extensive ulceration of the muscles of the abdominal wall, which had come on after a protracted labour. He thought it might have been produced by too violent pressure.

Other methods were also used in the treatment of cases of protracted labour (*nga wahine whakatina*), the chief of which consisted in the repetition of charms and incantations to the god or goddess of parturition. In some cases, on the arrival of the *tohunga* he stepped over the woman, breathed on her, and afterwards, retiring to a short distance, sat down and repeated his incantations. If the labour terminated favourably it was looked upon as resulting from the influence of the medicine-man in averting the anger of the demons; but if it terminated fatally the *tohunga* was considered to have incurred the displeasure of the malignant spirits, and to have lost his influence (*mana*). Difficult labour was not attributed to mechanical causes or physical defects, but to the influence of evil spirits, and was treated accordingly. In the case of a chief's wife or any woman of importance, the seer (*matakite*) is called to discover by clairvoyance or other means the particular breach of the *tapu* law which is the cause of the trouble. The father of the child then plunges into the river, while the *tohunga* repeats his *karakia*, and the child will generally be born ere he returns. The Arawa Tribe used the following *karakia* in such cases:—

* From White's "Ancient History of the Maori."

O Hineteiwaiwa, release Tu-huruhuru;
O Rupe, release your nephew.

The ancestors of the father were then invoked by name: first the elder male line of ancestors, commencing with an ancestor who lived in Hawaiki, and terminating with the living representative of that line. Then followed a repetition of the ancestral line next in succession, and the third in succession, if the child be not born; after which the *tohunga* addressed the child thus: "Come forth. The sin rests with me. Come forth." And he then continued his incantations:—

Unravel the tangle, unravel the crime;
Untie *manuka*, let it be loosed.
Distant though Rangi [the Sky Parent]
He is reached.

If the child be not now released, Tiki, the demi-god, is thus invoked:—

Tiki of the heap of earth,
Tiki scraped together
When hands and feet were formed,
First produced at Hawaiki.

If the child be a male it will now be born; if a female, the mother's line of ancestors must be invoked.

Hineteiwaiwa, or, as she is sometimes called, Hinauri, or simply Hine, the sister of Maui, and the best-known of all Polynesian legendary personages, was always approached in times of painful or delayed labour, and one of the most ancient of Maori *karakia* is that which they use when seeking the aid of this good goddess of parturition. It is said to have been first used at the birth of her son Tu-huruhuru, many ages ago. As it is fully translated elsewhere,* I only give a portion of the incantation:—

Weave, weave the mat,
Couch for my unborn child.
Now I step upon the mat,
My child now one with myself.
Stand firm, prop of Hine-rauwharangi,
Stand firm, prop of Hine-teiwaiwa.
Chide me not in my trouble,
Me Hine-teiwaiwa, O Rupe.
Release from above your hair,
Your head, your shoulders,
Your breast, your liver,
Your knees, your feet,
Let them come forth.
The old lady with night-dark visage,†
She will make you stretch,
She will make you rise up.
Let go placenta, let go membranes,
Come forth.

* "Maori Religion and Mythology," Shortland, p. 28.
† Hine-nui-te-po, the mother of the female ancestors of mankind.

The above *karakia* is still in use with the Arawa Tribe, and another frequently used is called *tuku* (to let go). Tura, the obstetric god, whose wife was the first woman delivered in the natural way (Cæsarean section being previously always performed), thus instructed his wife prior to her first confinement: "If your child is not born soon you must call Ao-nui (great world) and say, 'One to that world'; Ao-roa (long world), and say, 'One to that world'; and Ao-tauira (world of the disciple), and say, 'One to that world.' If then the child is not born you must call my name, and say, 'One to Tura.'"

"When there is much difficulty in parturition, the attendant, squatting before the patient, will press or rub her bare knees, with a downward motion, on the abdomen of the woman in labour, in order to aid expulsion. In some such cases the child is extracted forcibly by traction by the attendant midwife. The attendant was sometimes changed in cases of difficult birth, as natives have a firm belief in lucky attendants. A woman's husband sometimes attends her, but if the birth is not easy she will tell him to retire and to send her a capable woman." (Tuhoe.)

"After parturition a woman often betakes herself to a river or stream and immerses her body therein, lying on her back, and her attendant passes her bare foot downwards over the abdomen and uterus, so as to assist in the expulsion of any fragments of *whenua* (placenta) or *toto* (blood-clots)." (Tuhoe.)

In Fiji the midwives introduce the hand into the uterus, and, flexing the fingers, clear out all the clots they find.

There seems to have been no special treatment employed in the morbid states which sometimes follow parturition. The Maoris did not seem to attribute such troubles to sorcery, as did the Fijians. The latter often killed the child if the mother showed any morbid symptoms after labour, so as to favour her recovery. They kept a still-born child in the house for several days so that the mother might speedily recover.

The Maori woman after labour is sacred (*tapu*), and remains so until the time of baptism, or, if there is any morbid condition present, such as unusual pain or hœmorrhage, she remains *tapu* and lives apart in the sick-house until well. Generally, however, only the wives of chiefs are subject to this rigorous custom. She is rendered *noa*, or the *tapu* is removed, by the priest repeating the *tuapana karakia*.

Soon after the birth of the child the woman is given a vapour bath medicated with the three shrubs *mangeo*, *kohutuku* (*Fuchsia excorticata*), and *tataramoa* (*Rubus fustialis*). This is done to promote the lochial discharge, or, to use their own expression, "to make the blood come from them." They use this

generally twice—once soon after the child is born, remaining exposed to the steam for about the space of an hour, and repeat it for the same length of time on the following day; they also drink at the same time warm water in which a small fish, called *mohi*, has been soaked. This is, I presume, a substitute for chicken-broth or beef-tea, and is taken as nourishment. The wife of an ancestor named Uiroa brought forth a son, who was called Tahito-tarere. The people of Te-we presented warm water to her: hence this is provided by the relatives in all similar cases.*

If the breasts fail to secrete milk the woman sends her husband for the medicine-man, and the mother and child are carried to the sacred pool, where the *tohunga* dips a handful of weed into the water and sprinkles the mother and child with the "holy water." The child is taken away from the mother by the priest-physician, who then repeats this invocation:—

Water springs from above give me
To pour on the breasts of this woman;
Dew of heaven give me
To cause to trickle the breast of this woman,
At the points of the breasts of this woman,
Breasts flowing with milk,
Flowing to the nipples of the breasts of this woman,
Milk in plenty yielding;
For now the infant cries and moans
In the great night, in the long night.
Tu the benefactor,
Tu the giver,
Tu the bountiful,
Come to me, to this *tauira*.

After this the child is dipped in the water, and the mother and child are kept apart, in order that the incantations may take effect. The woman remains alone in her house, while the *tohunga*, seated outside, repeats his *karakia*. The *tohunga* also instructs the woman thus: "If the points of your breast begin to itch, lay open your clothes, and lie naked." Some time after her breasts begin to itch, and the woman knows that the *karakia* has taken effect. Soon her breasts become painful, and she calls out to the *tohunga*, "My breasts itch and are painful; they are full of milk." Then the child is brought to the mother. Such is the power of the incantations of the Maori. If the mother has an insufficient supply of milk the child may be suckled by friends, and friends calling to see the lying-in woman, if they themselves were suckling a child, invariably gave the breast to the new child. Maori women who have never been pregnant occasionally suckle children. Dr. Batty Tuke† knew of one

* "The Ancient History of the Maori," vol. 1, p. 33.
† Edin. Med. Journ., vol. ix., p. 726.

instance of this, " and was sufficiently well acquainted with the woman herself and family to be free from mistake or misinformation. "

The woman while nursing is *tapu*, and forbidden, under pain of death, to touch the food which she eats with her own hands; and women who violate this prohibition, by eating a piece of fern-root, for instance, in the mode forbidden by the law of *tapu*, have been immediately killed and eaten.(?)*

It is well known that a Tasmanian woman would kill her new-born babe to permit a favourite puppy being reared by suckling. The puppy was of greater value to the community of hunters than the babe. Maori women used frequently to be seen suckling a sucking-pig, either from affection for the animal or because they could not find children who required foster-mothers.

The leaves and bark of the native cedar, *kohekohe* (*Dysoxylum spectabile*), when macerated with water, were used by women who had lost their infants, to prevent the secretion of milk. Sore breasts were treated by the application of the oil of the *titoki* fruit (*Alectryon excelsum*), and the oil *hinu-kohia*, prepared by bruising the seed of the *kohia* (*Passiflora tetrandra*) into a pulp and heating the mass in a native oven, and then expressing the oil by pressure. " Another method of promoting lacteal secretion was to bathe the breasts with warm water. If this were neglected a serious condition termed *u taetae* would be set up in them." (Tuhoe.)

Koro-kio-ewe was a deity who presided over childbirth, and did his worst to unfortunate females in that state. Taiepa, an infernal demon, was one of his attendants or assistants.

At the cutting of the umbilical cord just after birth certain ceremonies were performed. In the first place, the *tohunga* repeats a charm over the child at that moment. If it be a male the charm is as follows :—

> Cutting to inspire you with courage to fight,
> Cutting to give strength to wield your weapon,
> Cutting to fill you with courage,
> Cutting to make you till food to eat, &c.

And so on, enumerating the various duties and qualities befitting a male. If, however, it be a female, the charm is as follows :—

> Cutting to make you weave the robe to keep you warm,
> Cutting to make you till food to eat,
> Cutting to make you hackle flax to weave with, &c.

Umbilical hernia is common amongst Maori children, and seems to be due to the custom of twisting the cord, or to its being

* Women were probably *tapu* in this manner only with their first-born child.—E. B.

cut too close. The condition disappears as the child grows older. The Maori child, having been washed, has all its joints manipulated and bent, and finally, to add to its beauty, the nose is pressed flat against the face, a prominent nose being considered extremely ugly.

"The umbilical cord has three subdivisions. The end next the child is termed the *pito*, that attached to the placenta is called the *rauru*, while the middle portion is known as the *iho* (see *ante*). Should the cord happen to break towards the placenta end during labour, such is termed a *rauru motu*, and the mother's life will be in great danger—no one save a very expert *tohunga* can save her; the child also will be stunted and puny. On account of this belief, a sickly or small person is often termed a *rauru motu*. If the *iho* has a knotted appearance, it is believed that the woman's next child will be a boy. The Maori was not acquainted with the function of the umbilical cord, but believed that the child received sustenance from the mother through the fontanelles (*wahi tamomo*) of the skull." (Tuhoe.)

The new-born babe, if a first-born child of a chief, is a very sacred object, and must first be rendered *noa* or free from *tapu*. The *tohunga* accordingly makes a number of clay balls, setting them in a row on the ground, and raising little mounds of earth near them; these mounds were named after the principal gods, and the clay balls were named after the ancestors of the child. The priest then takes a branch of the sacred *karamu* (*Coprosma*), *ake*, or other suitable plant, and, fastening a portion to the child's waist, repeats the appropriate *karakia*, called *tuapana* (which removes the *tapu* also from the mother, as already stated), and the ceremony is over. The *horohoronga* is part of a ceremony to take the *tapu* off a new-born child; it consists in preparing an offering by cooking certain food in three separate ovens, one of which is set apart for the family gods, one for the priest, and one for the parents. Girls were dedicated at their birth to Hineteiwaiwa, goddess of child-bearing and of all the necessaries of life.

Dentition is occasionally accompanied with irritation and convulsions, but the latter complaint is less frequent than among European children. The following charm is used by Maori mothers to hasten the process of teething:—

Growing kernel, grow,
Grow, that thou mayest arrive
To see the moon now full.
Come, thou kernel,
Let the tooth of man
Be given to the rat,
And the rat's tooth
To the man.

Twins (*mahanga*) and triplets have been known among the Maoris, but were not frequently seen, and three children born at one time have never been reared. Maori women often give birth to large families. One case is reported of fifteen children by one woman.

Premature labour and miscarriages were not uncommon; in fact, one well-informed medical man states that the latter were of frequent occurrence, many females suffering as often as from two or three to ten or twelve times. Whether this was the result of procuration, or simply accidental, he was unable to say; but he had strong suspicions that the former was frequently put into practice. The native woman, however, was subject to many accidental causes of such a condition. Dr. Dieffenbach stated that many children were still-born; but he suspected that in almost all these cases death was caused by the mother.

Various methods were resorted to to bring about the unnatural condition which was termed *whaka tahe, mate roto* (to die within), or *tutae atua* (lit. "excrement of the gods"). In some instances herbs were taken, such as a decoction of the *kareao* (*Rhipogonum scandens*); in others the desired end was obtained by pressing violently upon the abdomen with a belt; and, in addition, they had some instrumental method, but its precise nature is unknown. It does not seem to have been in very general use.

"According to Maori belief, premature birth was usually caused by some infringement of the laws of *tapu* on the part of the mother, and for which she would be thus punished by the gods. When a woman, in former times, desired to procure abortion on herself she would proceed to *taiki* the fœtus—that is, she would pollute a *tapu* person, as a *tohunga*, or one of her elders, by passing some cooked food over his garment or his resting-place. Or she might take a portion of cooked food to some sacred place and there eat it. Such acts would, to the native mind, be deemed quite sufficient to cause a miscarriage. Generally when a woman noticed that she was *papuni—i.e.*, that menstruation had stopped, and she was pregnant—and desired to procure abortion, she would proceed to some sacred place, as the *tuahu*, where priests performed various religious rites, and she would pluck some herb growing there, and, applying it to her mouth, would then cast it away. This would be quite sufficient: she has 'eaten,' or polluted, a sacred place. The gods will attend to her case." (Tuhoe.)

"A child born with a caul (*noho kahu*) will, it is said, grow up pert and forward, and will be a famous fighting-man.

The greasy substance (*vernix caseosa*) which often covers the skin of a new-born child is believed by the Maoris to be "food

consumed by the mother; and also it indicates, when unusually abundant, that the mother has not been so virtuous as she might have been." (Tuhoe.)

Among some tribes some singular beliefs obtain regarding birth—*e.g.*, that female children are never born while certain winds prevail, and that some winds prevent any birth, be it a male or a female child.

"The placenta has been described by natives as *he timatanga noho no te tamaiti* (a first abiding-place of the child). It is taken away from the village and buried, being *tapu*, as is also the place where it is buried, which is carefully avoided by the people. The village priest performed a rite over the placenta in order to cause the next child born to the woman to be healthy and vigorous, and to survive." (Tuhoe.)

"In late times, since the arrival of Europeans, the Maoris have used a certain decoction, which is drunk by women in order to cause the placenta to be expelled. It is made by boiling together the leaves of the *kopakopa* (*Plantago major*), clover, and *pororua* (*Sonchus oleraceus*) with some salt." (Tuhoe.)

"The natives believe that if a woman just pregnant sees some object which impresses her, or makes her laugh, then the child will be affected by this 'maternal impression.' For instance, should a woman in such condition be struck with the appearance of a *tekoteko* (a grotesque carved wooden figure) and laugh at it, her child when born will be very ugly. One woman who has a strand of reddish hair among her plentiful growth of black hair states that it was caused by her mother seeing. and being struck by, or interested in, some *maurea* (a reddish tussock grass) which had been brought from Tarawera during her pregnancy." (Tuhoe.)

Birth by the Cæsarean Operation.—This method of delivering the child is not infrequently resorted to in civilised countries in cases where the child cannot be born alive in the natural manner. The operation was known to the Romans, but was not commonly performed in Europe until comparatively recent years. Felkin saw a case of the Cæsarean operation in Central Africa performed by a native. Maori tradition records the discovery of the Naku-mai-tore, or Aitanga-a-nuku-mai-tore, a fairy or elvish people, by the gods Whiro and Tura. They were peculiar in shape, their legs and arms being so short that they seemed to have no limbs at all. Their chests and waists were large and their heads were small. They were not human beings. According to Moriori tradition these creatures were Rupe's people. They were wood-pigeons (*pare*, or *parea*), and are said to have got their red bills owing to the stain of Hine's blood, in assisting to deliver her child. They haunted the leaves and

fruits of the *kiekie* (*Freycinetia*) and the *wharawhara* (*Astelia banksii*); they sat among the foliage, waving their hands and short arms. Their children were always born by the Cæsarean operation.

Tura, also called Wai-rangi-haere (demented wanderer), left Hawaiki, the cradle of the Maori race, and travelled by sea to Otea, in the interior of which country he discovered the strange fairies, one of whom, Turakihau, he made his wife, and in due course she conceived. He was surprised one day, when the birth of the child drew near, by finding his wife in great sorrow; and she informed him that she was weeping because of her approaching death, it being the custom of the country to deliver the child by cutting open the mother's belly and extracting the child by making an opening into the womb, the death of the mother being a certainty under the rude surgical instruments of sharp flint used by the midwives. Tura reassured his wife, and drove off the fiendish midwives, allowing the infant to be born in a natural manner. Thus Tura became a deity who was appealed to in cases of difficult parturition, his wife being the first person ever delivered in the natural way. Had Tura allowed them to follow their own practice the body of the mother would, after delivery, have been taken to the Wai-ora-tane (life-giving waters of Tane), and there washed and bathed until life came back again and perfect health was restored.

Another story* relates how Manini-pounamu went away to sea and landed in a strange land, where he took to himself a new wife. "After a time, when the woman had been *enceinte* for two months, a party of twenty women went to visit her. The purpose for which they went was to rip open the woman. They were sent away, and when they returned later on the wife said to them, 'My husband would not consent to my child being cut out; he was very angry.' To this the women replied, 'But you will die.' Then the woman fell asleep in her house, and whilst she slept the visitors cut her open and saved her child, but the mother died."

In the traditions of the people of Niue Island we find the interesting legend concerning Gini-fale, often also called Mata-gini-fale or Gigi-fale. While sitting by the sea-shore she annoyed a whale, who in revenge swallowed her and swam away to sea. The monster became stranded on an island called Toga or Tonga, and Gini-fale escaped and got ashore. "The people of the island came down and found the woman, whom they took and cared for. She was a handsome woman was Gini-fale, and a certain chief of the island took her to wife. When the woman became pregnant, the husband used to cry every day. Gini-fale asked

* Journ. Pol. Soc., 1894, p. 103.

him, 'What do you cry for?' The husband said, 'I am crying on your account, because of your child.' It was the custom of that island to cut open the belly and then take the child out, but the mother died."*

Thus it is clear, from Maori legend, that the New-Zealanders had at least a theoretical knowledge of Cæsarean section. We have no proof that they ever practised it on the living female, and, knowing their great aversion to surgical procedures of all kinds, we think they probably never did. It is, however, extremely likely that the operation was sometimes performed on the bodies of victims in the wholesale slaughters which occasionally took place in their old-time tribal battles. In the subsequent cannibal orgie, if a woman in an advanced stage of pregnancy was consigned to the ovens her child would, we presume, be removed by such a procedure.

There is no recorded case of Cæsarean section amongst the Polynesians or Melanesians, although the latter also have legends attributing the operation to mythical personages.

PHARMACY: MEDICINAL PLANTS.

Ranunculaceæ.

Ranunculus rivularis. (*Waoriki.*)

The expressed juice, which has blistering properties, is used for rheumatic and other painful joint-diseases.

Clematis, sp. (*Pikiarero, Puawananga, &c.*)

The leaves used to produce blisters (counter-irritation).

Cruciferæ.

Brassica oleraceæ. (Wild-cabbage.)

A hot decoction was used internally in cases of colic.

Magnoliaceæ.

Drimys axillaris, Forst. (*Horopito*; Pepper-tree.)

The sap is used for the cure of skin-diseases and gonorrhœa. A decoction of the leaves (Maori painkiller) is often used by bushmen to allay abdominal pain.

Pittosporeæ.

Pittosporum obcordatum, Raoul. (*Kohukohu.*)

Used for itch, eczema of the scalp, and other cutaneous diseases. (See *ante*, "Skin-diseases.")

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* Journ. Pol. Soc., vol. xii., p. 102.

Pittosporum eugenioides, A. Cunn. (*Tarata.*)

A resinous balsamic gum obtained by making longitudinal grooves in the bark. Is used for foul breath.

Malvaceæ.

Hoheria populnea, A. Cunn. (*Houhere.*)

The leaves, bark, and flowers (glutinous like the mallow) of this tree are used medicinally.

Geraniaceæ.

Pelargonium australe, Willd. (*Kopata.*)

A lotion prepared from the bruised leaves is applied to scalds and burns.

Rutaceæ.

Melicope ternata, Forst. (*Wharangi.*)

The gum of this tree is chewed by the Maoris for foul breath. Care has to be taken not to confuse this plant with *Wharangipiro* (*Olearia cunninghamii*), the gum of which is a deadly poison.

Meliaceæ.

Dysoxylum spectabile, Hook. (*Kohekohe;* Native cedar.)

The leaves and bark are used as a bitter tonic and stomachic. A decoction of these parts of the plant was also used to allay coughing, and to arrest lacteal secretion. The young bark is said to contain a bitter principle having tonic properties allied to quinine.

Sapindaceæ.

Alectryon excelsum, D.C. (*Titoki, Titongi.*)

The green oil extracted from the fruit is applied externally to wounds, sores, weak eyes, sore breasts, chafed skin in infants, bruises, painful joints, and into the ear to relieve earache. Taken internally it is laxative. The astringent red pulp is taken by consumptives to relieve blood-spitting. (See *ante*, "Pharmacy.")

Coriareæ.

Coriaria ruscifolia, Linn.; syn. *C. sarmentosa*, Forst. (*Tutu, Tua-tutu, Tu-pakihi, Puhou.*)

Mr. F. L. Armitage informs me that this plant, although the most poisonous in New Zealand, is used in cases of sickness. For instance, a decoction of its leaves is given to patients suffering from dysentery; a mixture containing the juices of the pith is

used in insanity. The juice of the so-called berries (*pakaraka*) fermented with sea-weed (*karengo*) is taken to counteract the costiveness caused by eating *totara*, *rimu*, or *karaka* berries. From the leaves steeped in water with other plants is made a lotion used as an application to wounds.

Leguminosæ.

Edwarsia microphylla. (*Kowhai.*)

An infusion of the bark of the *kowhai* and *manuka* trees is drunk for internal pains, and is applied externally for pains in the back or side. The inner bark of *kowhai* is used for *hakihaki* (itch).

Rosaceæ.

Rubus australis. (*Aka taramoa, Tataramoa;* Bush-lawyer.)

The bark of this climber is boiled and the liquor taken as a purgative in cases of severe abdominal pain. If it does not act quickly, a decoction made from the *tawhero* is taken. It is also used in the vapour bath taken by women during the puerperium to promote lochial discharge. A decoction is taken to relieve dysmenorrhœa.

Geum urbanum, Linn. (*Kopata.*)

The astringent properties of the leaf are utilised in diarrhœa and dysentery, and are also chewed for foul breath (Armitage).

Acœna sanguisorbæ, Vahl. (*Hutiwai, Piripiri.*)

The leaves, boiled or steeped in hot water, are applied to open wounds, or rubbed on contusions. A lotion similarly prepared is applied to the external genitals (in women ?) in cases of painful micturition (E. Best). The plant is also used medicinally by the South Island natives (Hooker).

Saxifrageæ.

Weinmannia racemosa, Forst. (*Tawhero, Towai.*)

The bark from the west side of the tree, from which the outer rind has been scraped off, is steeped in hot water, and the decoction taken internally as an aperient in cases of abdominal and thoracic pains.

Haloragеæ.

Cercodia erecta, Murr. (*Toatoa.*)

A stiff-growing herb, used medicinally by the Maoris. (T. Kirk.)

Myrtaceæ.

Myrtus obcordata. (*Rohutu.*)

A preparation of the bark and berries is used by the Tuhoe natives in cases of dysmenorrhœa (difficult menstruation).

Leptospermum scoparium, Forst. (*Manuka.*)

The emollient, manna-like white gum (*pia-manuka*) is applied to scalds and burns, and is given to costive suckling infants. It is also taken by adults to allay coughing. An infusion of the bark is used externally and internally as a sedative. A decoction of the bark relieves diarrhœa and dysentery.

Metrosideros tomentosa, A. Cunn. (*Pohutukawa;* Christmas-tree.)

The inner tannin-bearing bark is used in dysentery. The honey obtained from the flowers is sucked through a reed by invalids with sore throat.

Metrosideros robusta, A. Cunn. (*Rata.*)

The flowers and bark used for the same complaints as *pohutukawa*. A lotion prepared from the bark is also used in ringworm, aches, pains, and wounds.

Metrosideros scandens. (*Aka-kura.*)

The sap is used by the Tuhoe tribes for weakness of the eyes (Best).

Passifloreæ.

Passiflora tetrandra. (*Kohia.*)

The oil expressed from the seeds (*hinu-kohia*) is applied to chronic sores and chapped nipples.

Rubiaceæ.

Coprosma grandifolia. (*Manono.*)

The sap obtained from the inner bark is applied in cases of *hakihaki*—scabies (Best).

Compositæ.

Brachyglottis repanda, Forst. (*Rangiora, Pukapuka.*)

The bark of this shrub and the tips of the branches on the west side of the plant are cut, and an aromatic gum exudes, which is chewed for foul breath. It may be first dissolved in oil, or may be kept soft in water.

Lagenophora forsterii. (*Parani;* Native Daisy.)

The sap was used for *maoa* (alveolar abscess) in the mouth (E. Best).

Sonchus oleraceus. (*Tawheke, Pororua;* Sow-thistle.)

Used medicinally (J. White). With clover and *kopakopa* it forms an ingredient of an ecbolic mixture (E. Best).

Loganiaceæ.

Geniostoma lingustrifolium. (*Hanehane.*)

Applied to a skin-disease of children (*hawaniwani*) (E. Best).

Convolvulaceæ.

Ipomœa batatas, Lam. (*Kumara*; Sweet-potato.)

The whole plant is boiled and the liquor used internally for low fever, and externally for various skin-diseases.

Solaneæ.

Solanum laciniatum. (*Poroporo.*)

The inner layer of the bark is used for *hakihaki* (scabies), and the leaves as cataplasms for ulcers.

Scrophularineæ.

Veronica salicifolia, Forst. (*Koromiko, Kokomiko, Kokomuka.*)

This is perhaps the most generally diffused plant in New Zealand. It is also the best-known medicinal plant, being used equally by native and settler. Its well-defined astringent properties render it a valuable drug in dysentery and diarrhœa. A few of the young fresh leaves are chewed and swallowed, or, being pounded with a mallet, they are then boiled for two hours or less: the resulting decoction, after filtration, is taken internally for the above-mentioned complaints. Baber* found that an infusion of the dried leaves had no therapeutic effect, but that a decoction had. From this he supposed the active principle differed from tannin. The leaves and tender shoots are used as a poultice for ulcers and venereal disease. *Koromiko* is also used in the native medicated steam or vapour bath.

Gesneriaceæ.

Rhabdothamnus solandri. (*Kaikai-aruhe.*)

The fresh leaves and twigs are used in the medicated vapour bath.

Verbenaceæ.

Myoporum lætum, Forst. (*Ngaio.*)

The bark is chewed for toothache, the twigs and leaves to medicate the vapour bath, and the juice expressed from the leaves is applied to the skin to prevent mosquito and sandfly bites.

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* "The Chemist and Druggist of Australasia," 1886, p. 268.

Plantagineæ.

Plantago major. (*Kopakopa.*)

"This plantain closely resembles the European, but is indigenous, and a valuable medicinal herb, well known to the Maoris. The leaves when boiled are used as an application for ulcers. The upper side of the leaf 'draws,' and when the wound begins to heal the under side of the leaf is used on it. The liquor in which the leaves are boiled is also used for scalds and burns, and as a uterine stimulant."

Lauraceæ.

Tetranthera calicaris. (*Mangeo, Mangeao.*)

Used in the vapour bath by lying-in women to promote the lochial discharge.

Monomiaceæ.

Atherosperma novæ-zealandiæ, Hook. (*Pukatea.*)

The inner layer of the bark of this aromatic plant is boiled in water, and the decoction thus prepared is applied externally to tuberculous and chronic ulcers, and various cutaneous diseases. A strong decoction held in the mouth relieves odontalgia, and is also taken internally and applied locally in syphilis.

Hedycarya dentata, Forst. (*Kaiwhiria.*)

Used in medicated vapour bath.

Piperaceæ.

Piper excelsum, Miquel. (*Kawakawa.*)

The leaf and bark are used for cuts, wounds, cutaneous disorders, gonorrhœa, and in making vapour baths. The leaves are chewed for toothache, and the root for dysentery. A pulp of the leaves is applied to joints in rheumatism. A decoction of the leaves and young shoots is taken internally for abdominal pains. This plant does not possess the sedative and narcotic properties of *kava* (*P. methysticum*).

Coniferæ.

Podocarpus totara. (*Totara.*)

The smoke from the burning wood is used to cure *paipai* (a cutaneous disorder), and venereal disease in women. The outer dry bark is used for splints in cases of fracture.

Dacrydium excelsum. (*Kahikatea.*)

The leaf is used in the form of a decoction for urinary and other internal complaints, and in the medicated steam bath.

Podocarpus ferruginea. (*Miro, Toromiro.*)

The oil expressed from the drupes is given to patients recovering from fevers. It is also applied to the skin as an insecticide. The gum which exudes from the bark is applied to wounds and ulcers. A liquor prepared from the leaves and bark is taken internally for *paipai* (gonorrhœa) by the Tuhoe natives (Best).

Dacrydium cupressimum. (*Rimu;* Red-pine.)

This excessively astringent gum, obtained by making incisions in the bark, is applied to wounds as a hæmostatic. The inner bark is bruised to a pulp and applied to burns.

Liliaceæ.

Phormium tenax, Forst. (*Harakeke;* Flax.)

The root is used as an anthelmintic and cathartic. It is applied to ringworm, and to the skin of young children to prevent chafing. The roasted root, beaten to a pulp, is applied to abscesses and swollen joints, in the form of a poultice. A decoction of the root with an equal portion of the juice of the *kohia*-berry is taken internally for flatulency. The alkaline gum is applied to wounds and burns, and is taken internally in cases of diarrhœa.

Rhipogonum parviflorum. (*Kareao;* Supplejack.)

A decoction is used for the secondary symptoms of syphilis, and to produce abortion. The young shoot is eaten to cure the itch (*hakihaki*); the long underground rootstocks skinned and then beaten to a pulp and steeped in water and strained, the liquor being used medicinally.

Cordyline australis. (*Ti.*)

A decoction is used by the Maoris for dysentery and diarrhœa.

Palmeæ.

Areca sapida, Soland. (*Nikau.*)

The slightly laxative pith is taken by pregnant women to relax the pelvic ligaments and thus facilitate parturition.

Gramineæ.

Hierochloe redolens. (*Karetu.*)

Used in the medicated vapour baths.

Arundo conspicua. (*Toetoe;* Feathery-grass.)

The feathery part of the plant is applied to wounds, acting mechanically as a hæmostatic. The ashes of the burnt plant

are applied to burns (*i.e.*, charcoal poultice). In diarrhœa the lower part of the young undeveloped leaves are eaten. The Morioris also used the plant medicinally."

Filices.

Pteris aquilina, Linn., var. *esculenta*. (*Marohi, Takaka, Rarahu, Rahurahu, &c.*)

The root of this common fern is used as food for invalids, and it is always taken by persons going on a voyage as the best antidote for sea-sickness.

Cyathea medullaris. (*Mamaku.*)

The bruised pith is used as a poultice for swollen feet and sore eyes.

Cyathea dealbata. (*Ponga.*)

The pith of this tree-fern was used as a poultice for cutaneous eruptions.

Asplenium obtusatum. (*Paretao.*)

This fern was used in the medicated vapour bath.

Hypnum clandestinum. (*Angiangi.*)

This fern was dipped in water and applied to the affected parts in cases of venereal disease. It also served as a diaper for menstruating women.

Musci and Lichens.

Mosses and lichens found on trees, when dried and reduced to powder, are rubbed into the skin for various cutaneous diseases.

Algæ.

Laminaria sp. (*Rimu-roa.*)

A long marine alga which grows on the rocks on the sea-coast. Its tender end is roasted and eaten as a cure for itch (scabies) and intestinal worms.

Laminaria sp. (*Karengo.*)

This seaweed, when fermented with the juice of the poisonous *tutu*, is used as an aperient.

ART. II.—*Notes on Ancient Polynesian Migrants, or Voyagers, to New Zealand, and Voyage of the "Aratawhao" Canoe to Hawaiki.*

By ELSDON BEST.

[*Read before the Auckland Institute, 12th September,* 1904.]

IN regard to the peopling of New Zealand by the Polynesian race, that event is usually referred to the fleet of canoes which arrived on these shores about twenty generations ago, simply because that migration is the only one of which any clear and connected account has been retained by the natives. The reason of this is probably because the people who came on board the "Arawa," "Tainui," "Matatua," "Aotea," and "Kurahaupo" vessels were of a more vigorous, warlike, and aggressive nature than the old-time people of these isles, a prior migration, or migrations, of Polynesians whom the newcomers found in possession of this country. The latter people intermarried with the original settlers, and, when they acquired strength of numbers, often fought them, and by these two modes of procedure became the dominant people of the land. Judging from information obtained from the descendants of the so-called autochthones, it would appear that the original people were of by no means a warlike nature. Hence, as time passed on, the power and prestige of the latter migration waxed ever greater, while that of the first-comers waned in proportion. Even so, we can acquire but little information as to the origin or whence of the first settlers in these isles; in some cases they have not retained even the name of the vessel by which their ancestors reached these shores. In such plight is the Tuhoe, or Urewera, Tribe, who cannot now give a satisfactory account of the origin of their main line of descent—viz., that through Potiki, from whom this ancient people derive their old-time tribal name, for Tuhoe and Te Urewera are but modern names. This tribe is in part descended from the people who came in the "Horouta," "Oturereao," "Rangimatoru," and "Nukutere" vessels, albeit they can give but a very meagre account of those little-known canoes. The fact is that these original people of the land have been here so long that they have lost any connected or clear account of their origin which they may have retained in past centuries.

I will now give some account of two lines of descent by which the original people of the Bay of Plenty district trace their origin from the two ancient canoes "Te Aratauwhaiti" and "Rangimatoru."

"Te Aratauwhaiti."

In an article by Colonel Gudgeon, entitled "Maori Migrations to New Zealand,"* we find this remark: "'Te Aratauwhaiti,' said to have been the first canoe that ever came to New Zealand, and that Maku, the ancestor of Toi-kai-rakau, came therein," &c. It is doubtful whether Maku was an ancestor of Toi, the Wood-eater, but Tiwakawaka, the principal person on board "Te Aratauwhaiti," certainly was so. Moreover, my informants state that Maku did not come in that vessel, but that he visited New Zealand, arriving at Whakatane, subsequently, and found Tiwakawaka, or his descendants, living at Whakatane. He (Maku) then returned to Hawaiki—that is to say, to the isles of Polynesia.

In White's "Ancient History of the Maori," vol. i., p. 127, we find this remark: "*Ko te Ara-tau-whaiti o Tane, he waka*"—but nothing more.

The account given by the descendants of Toi of this old-time vessel is as follows: In times long passed away, when Maru, Haere, Kahukura, and other descendants of Tane quarrelled among themselves, then it was that Tiwakawaka came to this land, to Aotearoa. He came in the canoe "Te Aratauwhaiti" from Mataora. He found a lone land, for Aotearoa had no inhabitants when he arrived here. My informant is very particular to state that Tiwakawaka and Maku came from different lands—the former from Mataora, the latter from Hawaiki. He says, "In regard to the first people of this land, Tiwakawaka came from Mataora. He did not come from Hawaiki; he came from Mataora, and remained here, settling at Whakatane, which was known as Kakaho-roa to the ancient tribes. (*Ko Tiwakawaka, kaore i haere mai i Hawaiki, i haere ke mai ia i Mataora, i te kainga o ona tipuna, o Tane ma, o Tu, o Tangaroa, o Rongo, o Tawhirimatea, o Tangotango.*) Tiwakawaka was the first ancestor to dwell in this land. He was a grandson of Maui. He was the original ancestor of all the ancient tribes who dwelt here. The following tribes all sprang from him:—

Ngati-Ngainui
Te Tuoi
Te Tini o Te Makahua
Te Tini o Te Marangaranga
Te Rarauhe-turukiruki
Te Rarauhe-maemae
Te Tawa-rarau-ririki
Te Tururu-mauku
Te Tini o Te Kokomuka-tu-tara-whare
Te Tini o Te Kawerau
Te Raupo-ngaueue
Te Tira-maaka
Te Patupaiarehe.

In after-times it was Maku who came from Hawaiki and landed at Whakatane, where he lived a while with the people of Tiwakawaka, and then returned to Hawaiki. The saying of Maku

* "Journal of the Polynesian Society," vol. i., p. 217.

was this: "*Tiwakawaka i te pae tuarua o Aotea-roa.*" So Maku returned whence he came, nor did he ever come back to these shores; hence the old-time saying, *Maku hokinga tahi.* And the descendants of Tiwakawaka dwelt here even unto the time of Toi, who also sprang from Tiwakawaka, and to the time when the new people came from Hawaiki in "Matatua" and other canoes. I say that Tiwakawaka did not dwell in Hawaiki; his home was that of Pani. (*Kihai a Tiwakawaka i noho ki tena kainga, ki Hawaiki. No Pani tona kainga.*)

Here is the descent of our people from Tiwakawaka :—

Tane
Tane-tuturi
Tane-pepeke
Tane-ueha
Tane-ue-tika
Tane-takoto
Ioio-whenua
Te Ao-matinitini
Tangaroa-i-te-rupe-tu
Maui-tikitiki-o-Taranga
Te Papa-titiraumaewa = Maui-mua
Tiwakawaka = Rotua
Tara-nui
Tara-roa
Ngai-nui
Ngai-roa
Ngai-whare-kiki
Ngai-whare-kaka
Ngai-roki
Ngai-roka
Ngai-peha
Ngai-taketake
Ngai-te-huru-manu
Toi
Rauru

Hatonga
Tahatiti
Ruatapu
Rakei-ora
Tama-ki-te-ra
Tama-ki-hikurangi
Maru
Hine-te-ariki
Tapa
Ira-taketake
Tapui
Te Matapihi-o-rehua
Te Tauru-o-te-rangi
Te Uru-waewae
Te Pikitu-o-rehua
Te Uru-waea
Patu-pokohu
Kai-whakapae
Te Pori-o-te-rangi
Patu-pakeke
Tapuika-nui
Tumutara
Horiana
Renata

(Ngatiawa Tribe, Bay of Plenty).

According to various lines of descent, it would appear that the Polynesians have inhabited New Zealand for about nine hundred years, calculating on the basis of twenty-five years to a generation.

I am of opinion that Maku was a voyager who did not remain on these shores, or we should hear of his descendants,* and that he visited New Zealand at a time when the offspring of Tiwakawaka had increased and multiplied to such an extent as to occupy most of the North Island, if not the South also; for traditions preserved by the Ngatiawa Tribe assert that Maku found the land occupied "from one end to the other." Ngatiawa say that Maku came to this land of Aotearoa borne by a *taniwha* (water-demon), which, I take it, is equivalent to the admission that they do not know the name of his canoe.

Te Papa-titi-raumaewa, the mother of Tiwakawaka, married her father's brother, Maui-mua. This is probably the reason why native tradition asserts that incest originated with Maui. Another version has—

Maui-mua = Papa-tu-rangi
|
Tiwakawaka = Haumia-nui.

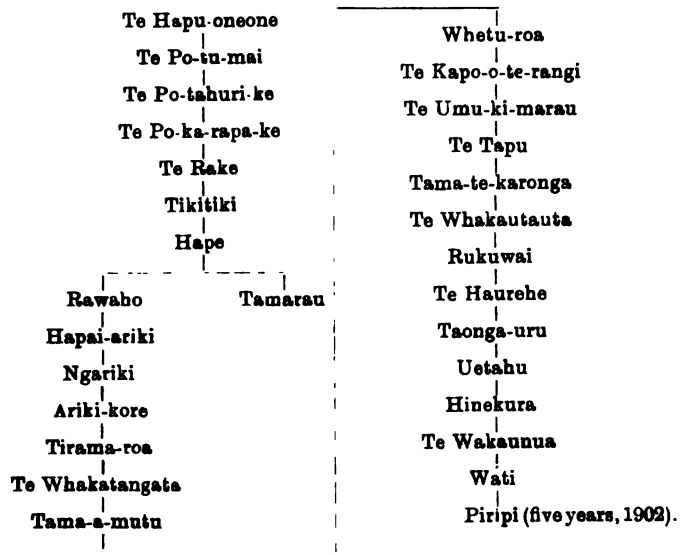
"RANGIMATORU."

The "Rangimatoru" canoe was another old-time vessel which reached these shores before the coming of the "Arawa" and sister-vessels, but at a time long subsequent to the arrival of the "Aratauwhaiti."

The "Rangimatoru" canoe came to land at Ohiwa. The principal man on board is said to have been one Hape, or, to give him his full name, Hape-ki-tu-manui-o-te-rangi, who is said to have wandered down to the South Island, where he died, a tradition which is supported by legendary evidence of the South Island tribes. Te Hoka-o-te-rangi is also said to have come to New Zealand on the "Rangimatoru." Some assert that this vessel was really the "Kurahaupo" canoe which had been abandoned by her crew as unseaworthy, and which was patched up by others and brought to New Zealand. If the Hapu-oneone Tribe of Te Waimana were descended from "Rangimatoru" migrants, then that canoe must have arrived long before the "Matatua," which latter vessel brought the original crew (or a portion thereof) of "Kurahaupo" to Whangaparaoa; for the Hapu-oneone were assuredly an ancient people of the Bay of Plenty district. If, however, the genealogies, given by many

* "*Ka hoki a Maku ki Hawaiki, tona whakatauki tenei. Hoki ake nei a Maku, to ake te tatau ki te whare. Oti tonu atu ki Hawaiki tera tipuna, kihai i hoki mai.*"

natives, of Te Hapu-oneone and Hape apply to the same man, then it is clear that the "Rangimatoru" must have arrived about the same time as the fleet of "Matatua," "Te Arawa," &c., as the following line will show :—



Tumutara, of Ngatiawa, stated to me that the "Rangimatoru" canoe belonged to Hape and Tikitiki-o-te-rangi, and seemed to imply that some of the "Aratawhao's" crew returned on board her. Another tradition of Ngatiawa contains a singular statement which would seem to mean that the canoes "Rangimatoru" and "Te Paepae-ki-Rarotonga" belonged to these original people of the Bay of Plenty, and that they accompanied "Te Aratawhao" to Hawaiki in quest of the coveted *kumara*.

Whether Hape was or was not the origin of the Hapu-oneone Tribe, it is certain that those people were some of the ancient inhabitants of the Bay of Plenty district, and were a numerous people when the historical fleet of canoes, "Te Arawa," "Matatua," &c., arrived from Hawaiki. They occupied the district from Ohiwa across to Ruatoki.

"OTURUREREAO."

The "Oturereao" canoe is another vessel about which we have very scant information, though the late chief Rakuraku, of Te Waimana, could have thrown some light thereon, inasmuch as he was a person possessed of much knowledge of Maori traditions, and was also a descendant of Tairongo, the chief of

the "Oturereao" canoe, from whom the Tairongo Tribe of Ohiwa derived their name.

This canoe made the land at Ohiwa, where her crew settled. It is said that she arrived about the time of the historic migration, and that she brought the *aute* shrub (paper-mulberry) to this land. Colonel Gudgeon states that Taikehu was the chief of the "Oturereao" canoe, and that Tairongo was chief of the people of Ohiwa when the vessel made the port. Hamilton, in his "Maori Art," gives "Oturereroa" as the name of a vessel which reached these shores from Hawaiki. This is probably a misprint.

I am inclined to think that my Ngatiawa informants are right, and that Tairongo was chief of "Oturereao," for they say of him, "Tairongo belonged to Hawaiki-nui. He was an important chief of that land, as also was Rongoatau. They lived at Te Whakao, at Hawaiki-nui."

"NUKUTERE."

This is another little-known canoe which reached these shores probably about the time of the coming of the "Matatua," or perhaps before, as the name is not coupled with that of the latter, as it would be if she was a member of the noted fleet.

The descendants of those who came in "Nukutere" are to be found among the Tuhoe Tribe, and those tribes living on the eastern shores of the Bay of Plenty as far as Ngatiporou.

Captain Mair states that Ngatorohaka came in "Nukutere," and gives a genealogy from him, twenty generations to the present time.*

Ngatiawa state that "Nukutere" made the land at Waiaua, and that among her crew were seven persons bearing the name of Tamatea. Also that one Roau came by that canoe, and brought hither the *karaka* (tree), the *ti* (*Cordyline*), and the *taro*, the two latter being known as *Te Huri a Roau*. The name of the *ti* was Whakaruru-matangi; it was planted at Pokerekere. The *karaka* was cultivated at Wai-o-weka.

Tamatea-nukuroa appears to have been the chief man of "Nukutere." His children were Roau, Rangiwaka, and Nga Tai-e-rua. His descendants are among the Whakatane Tribe of Te Waimana, and elsewhere. He appears to have been also known as Tamatea-kai-haumi, Tamatea-mai-tawhiti, and Tamatea-pokai-whenua. He is said to have lived for some time at Te Wera, but died at Waikato. One Tunamu is also said to have come in "Nukutere" from Hawaiki, but a genealogy given of him by Manihera Maiki does not support the statement.

* Trans. N.Z. Inst., vol. xxviii., p. 36.

Whironui is also said to have been a member of the crew of "Nukutere" by some, but my informants maintain that he came in "Horouta." If so, then he cannot have been identical with that Whiro who is said to have been the elder brother of Toroa of "Matatua," for "Horouta" probably reached these shores some five or six generations before either "Nukutere" or "Matatua."

"TE PAEPAE-KI-RAROTONGA."

Of this vessel very little is known, save that Waitaha-ariki-Kore was the chief thereof, and after whom Te Kauae-o-Waitaha, a place at Rurima, is named. The canoe is said to be lying at Tara-o-muturangi. Ngatiawa expressly state that this vessel arrived before the coming of "Matatua," and it is said to have been a very *tapu* craft; hence the place where it lay, or was abandoned, was used as a burial-place.

Waitaha married Hine-te-ariki, of the ancient Tini-o-Tuoi Tribe, and was an ancestor of Tuwhare-toa-i-te-au-pouri, of Kawerau, from whom the present people of Taupo derive their tribal name.

The "Paepae-ki-Rarotonga" landed at Tara-o-muturangi, near Matata, in the Bay of Plenty. According to Colonel Gudgeon the Rarotongan natives have a tradition concerning a canoe called "Te Paepae-o-Rarotonga."

"TUWHENUA."

The "Tuwhenua" canoe is not generally known in this district (Bay of Plenty), but some of Ngatiira, of Opotiki, state that Tamatea came from Hawaiki in that vessel, and that he found a tribe of aborigines living at Motu on his arrival.

"TAHU-UPOKO."

This has been given to me as the name of a canoe which one Kupe came in, but nothing appears to be known of it. The people of these parts confuse the ancient voyager Kupe with Kupe of the Takitumu people, albeit the latter flourished at a much later period.

"HOROUTA."

I shall have but little to say concerning this vessel, inasmuch as the traditions connected with her have already been published. "Horouta" seems to have arrived here some five or six generations before the fleet ("Te Arawa," "Tainui," "Matatua," &c.). Some of her crew remained here, and their descendants may be found among the Ngatiporou, Tuhoe, Ngatihau, and other tribes. Among the crew are said to have been Whiro-nui, Te Poutama, Iri-a-rangi, Te Kahu-takiri, Te Rakaupango, Te Kotore-o-hua, and one Whiro-tipua. On this

vessel, it is said, came a number of black-skinned men, who spake a different language to that of the Maori people. These black people were known as Ngai-Tamawhiro among the Maori, and are said to have been the tribe or descendants of one Whiro, but whether Whiro-nui or Whiro-tupua is meant is not clear. These people were probably Melanesians of Fiji. They lived near Matata, but gradually became extinct, or lost to view, probably through intermarriage with the Maori.

In addition to the crews of the above canoes, there are also traditions of other old-time voyagers who visited these shores in times long passed away, but whose names only are retained. Of these, the most widely known is Ngahue, who visited New Zealand prior to the coming of the historic fleet. He is said to have seen the moa here. Another was Tama-i-waho, also known as Puhao-rangi, who came to New Zealand in the time of Toi (see genealogy). His descendants here are well known. One Irakewa also appears to have reached the Bay of Plenty, just prior to the arrival of the fleet, in some unrecorded manner. A huge rock on the summit of Maunga-pohatu is known as Te Tapapatanga o Irakewa. Irakewa is said to have returned to Hawaiki, and from his descriptions and directions the crew of "Matatua" were enabled to reach Whakatane. There is much mystery concerning Irakewa and his movements. Some of Ngatiawa say that he was a descendant of Toi :—

Toi
|
Awanui-a-rangi
|
Awa-roa
|
Awa-tuma-ki-te-rangi
|
Pari-nui-te-ra
|
Irakewa
|
Awa-nui-morehurehu = Te Paereere-i-waho
|
Toroa.

This Toroa was the chief of the "Matatua" canoe which reached New Zealand with the historic fleet about eighteen or twenty generations ago. Irakewa may have been a descendant of Toi of New Zealand, but, if so, he must have gone to Hawaiki about the time that "Te Aratawhao" made her famous voyage to Polynesia. Awa-morehurehu is said to have been a member of the crew of that canoe. Our most learned man among Tuhoe states that Awa-morehurehu was the father of Irakewa, which would be much more credible.

Taneatua was another old-time wanderer who reached this land somewhere about the time of the arrival of "Matatua,"

but who is never given as a member of the crew of that vessel. His descendants are numerous among the Tuhoe Tribe.

Another old-time voyager was Pou-rangahua, of Turanga, Poverty Bay, he who married Kanioro, a sister of Taukata, of whom more anon. Puketapu, of Waikare-moana, states that Pou came in "Horouta," but that is not credible if he was a contemporary of Taukata and Hoaki. Pou was a chief of the ancient people of Turanga, and he went to Hawaiki—that is to say, to the isles of the north—in order to obtain the *kumara*. It is not known how Kanioro reached New Zealand. She may have come with her brothers, who brought the knowledge of the *kumara* to the Toi tribes of Whakatane, though Puketapu maintains that she came with Pou on "Horouta." The singular legend of Pou-rangahua and his adventurous trip hither from Hawaiki on "Rua-kapanga" I have recorded elsewhere. It may also be found in that most modern classic tome, "Maori Lore," the production of one Izett, who inserted it, without acknowledgment and wofully garbled, in that eccentric and ridiculous work.

Tamarau-apu was another voyager to New Zealand from the isles of Polynesia in times long passed away, but of whom little is known at the present time :—

Tamarau-apu
|
Tama-ewa
|
Te Mahoihoi-o-te-rangi.

This Mahoihoi was a contemporary of Waitaha-ariki-kore of the "Paepae-ki-Rarotonga" canoe.

Poutini is said to have been one of the earliest visitors to New Zealand, but his name and doings are so surrounded by myth that no clear account concerning him can be given. He is sometimes said to have been the discoverer of the greenstone, while many speak of him as being the personification of that prized stone.

Although we have no knowledge of any migrants arriving here since the famous fleet of from eighteen to twenty generations ago, yet Cook's interpreter understood certain Maoris to say that, subsequent to the arrival of their ancestors in New Zealand, some canoes had arrived from an island called Ulimaroa.

The Ngatiporou Tribe have a tradition that some of their ancestors left New Zealand to search for the Hawaikian fatherland, but were never again heard of. Shortland, in his essay published in the first volume of the "Transactions of the New Zealand Institute," mentions a canoe which left Tauranga in the last century, and sailed boldly forth into the Pacific Ocean in search of Hawaiki.

"Te Aratawhao."

Voyage of the "Aratawhao" Canoe to Hawaiki in order to obtain the Kumara.

I will now give a short account of the most important event in the history of the Bay of Plenty tribes—viz., the introduction of the *kumara*, or sweet-potato, whereby the lot of the aboriginal tribes was much improved. Previous to that important event the natives had but one cultivated plant, the *hue*, or gourd, which was, however, a very poor article of food, and could only be eaten in the early stages of its growth—*i.e.*, in the *kotawa* state. The vegetable foods of the aboriginal tribes were principally fern-root, *mamaku*, berries, various plants used as greens, also the young undeveloped leaves of various *Cordyline*, and the tap roots of at least one variety of *Cordyline*. Of these, the principal item was the *aruhe*, or fern-root, which was the great stand-by of the aborigines. Presumably the first settlers in New Zealand did not bring seed sweet-potatoes with them, although they brought seeds of the gourd, and also introduced dogs of the *ruarangi* breed.

About twenty generations ago the old-time fort Kapu-te-rangi, whose earthen walls still crown the cliffs of Whakatane, was inhabited by the descendants of Toi, among whom one Tama-ki-hikurangi was probably the most important chief. These people were known by the tribal names of Te Hapu-one-one, Te Tini-o-awa, &c. And it fell upon a certain fine morn that one Kura-whakaata, a daughter of Tama-ki-hikurangi, was walking on the beach, or bank of the river, beneath the pa mentioned, when she espied two strange men lying upon a rock hard by the river-side, and also heard them repeating the following invocation in order to cause the sun to shine brightly, and thereby warm their chilled frames, for they had undergone much hardship from exposure in their long canoe voyage from the isles of Polynesia:—

Upoko! Upoko! Whiti te ra
Tenei to wahine te aitia nei
E te aoao nunui, e te aoao roroa
Tu atu te makariri
Haramai te werawera
Haere mai te mahana
Torohei!

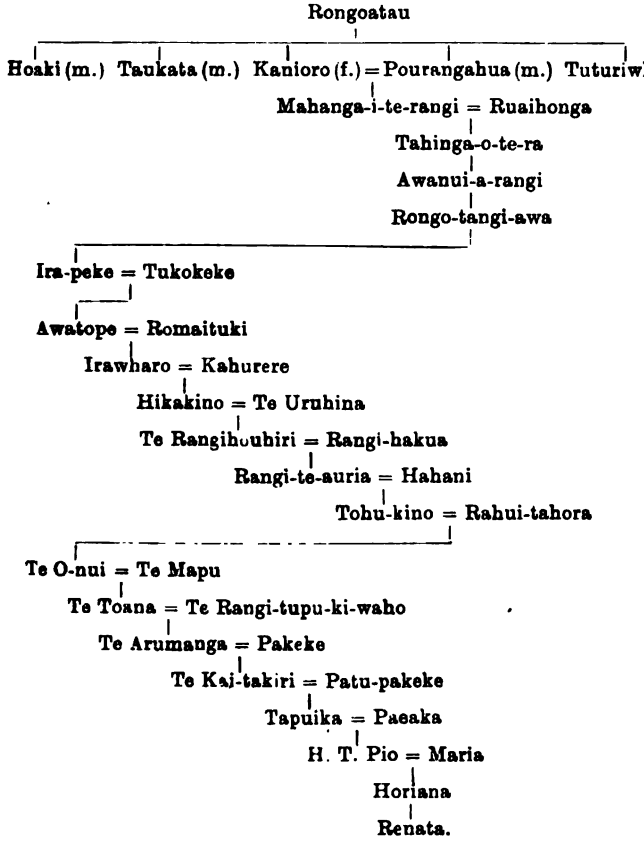
The following being a different version of the same:—

Upane! Kaupane! Whiti te ra
Tenei to wahine te aitia nei
E te ngarara nunui, e te ngarara roroa
Upoko! Upoko! Whiti te ra.

These two men were brothers named Taukata and Hoaki, sons of one Rongoatau of far Hawaiki, and they had made the long

and adventurous voyage to this land in a canoe named "Nga Tai-a-kupe," which is said to have been a *waka pungapunga* (*pungapunga* canoe), whatever that may have been. I should not think that pumice-stone (*pungapunga*) would make a very seaworthy vessel.

Now, as Taukata was subsequently slain at Whakatane, and his brother Hoaki returned home to Hawaiki on "Te Arata-whao," it follows that no genealogy from them is now known; but we have various lines from their sister Kanioro, who, as stated above, married Pou-rangahua of Turanga. The four names given were all children of Rongo-a-tau, a chief of a Polynesian people dwelling at a place named Te Whakao, at Hawaiki-nui:—



When the strangers had finished their prayers, Te Kura-whakaata asked, "From whence do you come?" They replied, "We come from Hawaiki, from Mataora." "So came these voyagers to Kakaho-roa, which was the ancient name of Whakatane, the name our ancestors gave it in times long passed away, long before the canoes arrived which brought hither the new people, the Maori who now dwell in Aotearoa."

Even so, the worn-out voyagers were conducted by Te Kura to Ka-pu-te-rangi, the fortress home of her father, Tama-ki-hikurangi, and his people. As Te Kura entered the ancient fort of Toi, she cried, "*He manuhiri kei ahau, Te Hapu-oneone, E!*" And the people were disturbed in their minds at this announcement, not knowing what this visit of strangers from a far land might portend. But they turned to prepare food for their guests, the foods of the men of old—fern-root, *mamaku*, and *ti* (*Cordyline*), and roots of the *raupo*, and earthworms. Then was heard the resounding blows of many mallets as the women crushed the fern-root. Taukata asked, "What is the loud sound we hear?" And Tama replied, "It is Haumia-roa." (Haumia-roa is a sort of emblematical term for fern-root.) When the prepared food was placed before the voyagers they showed no great appreciation of it. Taukata said, "The prized food of Hawaiki has arrived in Aotearoa." He demanded that a bowl of water be brought, and he then took from his belt (*tatua pupara*, the pocket of the old-time Maori) some dried *kumara*, which he pulverised and stirred into the gourd of water, the result being a sort of mush, which he offered to his hosts, who were delighted with the new article of food. They inquired, "How may this food be obtained?" Taukata replied, "By means of a canoe. You must construct a canoe and visit Hawaiki, where you will obtain the *kumara*." Now, the original people of New Zealand at that time seem to have given up the making of large sea-going canoes; anyhow, they put the matter into the hands of their visitors, who were asked to build a canoe for the purpose. This would seem to mean that the vessel by which Hoaki and his brother had come to Aotearoa had either been rendered unseaworthy or was too small for the required purpose. Anyhow, the visitors found a fine *totara*-tree stranded on the river-bank at Opihi, just across the river, and opposite the present Township of Whakatane. Of this they made a large canoe which was named "Te Ara-tawhao," so called because it was made from drift timber (*tawhaowhao*). The vessel was hewn out with stone tools named Te Manokuha, Te Waiheke, Te Whao-tapu-nui-a-tane, and Warawara-tai-o-tane. Taukata said, "You must go far across the seas to obtain the *kumara*. You must go to Pari-nui-te-ra

and to Ngaruru-kai-whatiwhati, where you will obtain the best seed, such as the *toroa-mahoe.*"

While "Te Aratawhao" was being prepared for her long voyage Pou-rangahua seems to have been present at Whakatane. He said, "Do not let our canoe sail forth until I have visited my child Kahukura, at Kirikino. When the sun rises he puts out his tongue in that direction; hence I believe that in that direction can be found suitable food for his mother—that is, to cause her to give milk freely." But when Pou returned from his visit home to Turanga he found that the "Aratawhao" had sailed for Hawaiki without him. Hence he took steps to reach Hawaiki on his own account; but we will leave the relation of his weird adventures on that trip for another time, and follow the fortunes of "Te Aratawhao," the vessel of Te Hapu-oneone, which crossed the wide seas to the distant isles of Polynesia.

Of those who formed the crew of "Te Aratawhao," I give below such names as have been preserved. Among them was Hoaki, brother of Taukata, one of the voyagers who brought tidings of the *kumara* to the Hapu-oneone of Whakatane, or, as it was then called, Kakaho-roa.

Crew of "Te Aratawhao" (Portion only).

Tama-ki-hikurangi (chief person on board)
Hoaki (taken as a pilot)
Tama-rakei-ora
Whata-kiore
Taunga
Te Puka
Te Whatu-iria
Awa-hei-nui
Awa-morehurehu
Tatapuku
Tama-ki-te-ra
Awa-hei-roa
Tahu-o-rehua
Mawake
Te Whatu-potango
Nuku-taria
Tikitiki-o-te-rangi
Ira-te-wehenga
Te Whatu-pouri
Kauae-puku.

Taukata remained at Whakatane, possibly on account of his sisters Kanioro and Tuturi-whatu* having settled in New Zealand, but Hoaki went on the "Aratawhao" to act as a guide for her crew to the far-off isles of Polynesia. Taukata and his brother are said to have supervised the building of "Te Aratawhao." It is probable that the Hapu-oneone had forgotten the art of building sea-going vessels at that time.

When "Te Aratawhao" was ready for sea, and about to leave Whakatane, Puhi-ariki proposed that Tama-ki-hikurangi be left behind, that they should sail without him, lest disaster befall the voyagers. This fear was perhaps caused by Tama's well-

* Or Tuturu-whatu.

known powers of magic, for he was a noted *tohunga* (priest, warlock, magician, shaman), and was high priest of the famous *pouahu*, or sacred place, at Whakatane. Tama heard of the above project, and declined to be left behind. He also managed to give his fellow-voyagers a fright. He bored a hole in the bottom of the canoe, and when they had lost sight of land pulled out the plug with which he had stopped the hole. The water flowed in until the crew became alarmed, nor could they find the baler until Tama, who had concealed it, produced it. He had also caused the wind and sea to rise by means of his magic rites (*ka hikaia te hau, me te kino o te moana*).

So the famed "Aratawhao" sailed forth from Whakatane upon the sea of Toi, and headed for the far-away isles of Polynesia. And this was the act which caused such an important change in the lives and domestic economy of the old-time people of New Zealand. For by the acquisition of the *kumara* they became an agricultural people, and by their voyage to Hawaiki they were the cause of the famous historic fleet of "Te Arawa," "Tainui," "Matatua," "Aotea," &c., coming to New Zealand. Had these people known that ere long they would lose their old-time power and prestige through the coming of a more energetic class of Polynesians, it is probable that Taukata and Hoaki would have met with a different reception than that accorded them, and that the title of "Wood-eaters" would have been applicable to the descendants of Toi for many more years.

But these old Vikings wot not of the buffetings which fate held in store for them, so sailed they across the great ocean to the home of their visitors. Still does the voyage of "Te Aratawhao" live in song and story among the descendants of Toi, the Wood-eater, and still they recite the tales of daring deeds performed by their ancestors in the days of the long ago.

After the long voyage across the Great Ocean of Kiwa, the "Aratawhao," battered and worn from her long cruise, arrived at Hawaiki, the home of Rongoatau, father of Taukata and Hoaki, who lived at Te Whakao.

On arriving at Hawaiki, Hoaki visited one Maru-tai-rangaranga, a chief of those parts, who greeted him with the following song:—

E hika! E hika!
Ka uea koe i runga te ata ura
Ki runga te ata mea
Maku e ki atu, pikitia e koe
I runga te ngaru nui
I runga te ngaru roa
Waerea e koe i tai
Ka pupuke i runga o te Moana nui a Kiwa
E takoto nei

Hurihanga a ngaru
Ki waho ki te moana
Turua mai e koe
Ki a Tu-hikitia, ki a Tu-hapainga
Aua mai nuku, aua mai rangi
Rukuhia e koe i te ruku i te kawau
Koia te rangi e tu nei—e—i.

As the people gathered round to greet him, Hoaki said to Maru, "Sir, I have a party with me." "Who are they?" inquired Maru. "They are the descendants of Toi." "For what purpose have they come?" "They tasted the dried *kumara* that we took with us, hence they have come to obtain the seed for planting."

So the voyagers obtained their seed, which was procured at Pari-nui-te-ra and at Ngaruru-kai-whatiwhati.

Below are given some of the incantations and spells used by the crew of the "Aratawhao":—

Ka hikaia ko te hau.

Hika atu ra taku ahi
Ki te hau e riri mai nei
E rotu mate, rotu mate aio he
Tawaha ana ra
Te hau e riri mai nei
E rotu mate, rotu mate, aio he
He marangai te hau
E riri mai nei
Haere i tua, haere i a moana nui
Haere i a moana roa
Haere i a moana te takiritia
Ki te whai ao, ki te ao marama.

The above spell is termed a *rotu;* it is recited in order to calm the angry surges, to calm the boisterous winds. The following is termed a *tata;* it is repeated while a canoe is being baled out when at sea:—

Pa atu hoki taku tata
Ki te riu tapu nui o te waka
E haere nei
Rei kura, rei ora
Rei ora te mahaki
Ka turuturua, ka poupoua
Ki tawhito o te rangi—e.

The following is the *awa* of "Te Aratawhao." The *awa* is an incantation used in order to render the course of a canoe calm and easy to pursue—to smooth the way for her. The word *awa* bears the meaning of "channel, course of a vessel":—

Tu mai awa, tu mai awa
Ko koe kai (kei) takahia noatia e au
Ta peau nuku, ta peau rangi
(or tupe au nuku, tupe au rangi)

Whati ki runga, whati ki raro
Ma uru marara
Pera hoki ra taku manu nui na Tane
Ka tatau atu ki roto nuku ngaere
Mai a whiwhia, mai a rawea
Mai a whakatakaia
Ka taka te huki rawea
Koro i runga, koro i raro
Koro i Tawhirimatea
Ki kona hoki koe tu mai ai
Ka hura te tamatea nunui
Ka hura te tamatea roroa
Te kauwaka nuku, te kauwaka rangi
Te ai a nuku, te ai a rangi
Te kura mai hukihuki
Te kaweau tetere
Kawea a nuku, kawea a tai
Oi ! Tumatakokiritia
Hoatu waka ki uta
Hoatu waka ki waho
Ngaru hinga atu, ngaru hinga mai
I runga te tama-wahine
I raro te tama-tane
Huki nawenawe
Tenei te awa ka whakairi
Ko irirangi te waka
Ko irirangi te tangata.

Such was the *awa* of "Te Aratawhao," which smoothed her path across the great waters, and sped her on her way.

Here followeth the *ruruku* of the "Aratawhao," which is a spell recited in order to "bind" a vessel, to keep her sea-worthy, &c. :—

Ka timata te ruruku o te waka, ka rukutia te kei o te waka, me te ihu.

Rukutia
Rukutia te waka e haere nei
Rukutia te kei matapupuni
Rukutia te ihu mata pupuni o Tane
Rukutia i te kowhao tapu nui o Tane
Rukutia i te mata tapu nui o Tana
Rukutia i te rauawa tapu nui o Tane
O te waka e haere nei
Tumatakokiritia
Rei kura, rei ora
Rei ora te mahaki—e
Ka turuturua, ka poupoua
Ki tawhito o te rangi—e
E manawa mai ao—e
Hoatu waka ki uta.

In regard to the return of these voyagers from the shores of Hawaiki, native authorities of the Whakatane district are unanimous in stating that the "Aratawhao" never returned to New Zealand, but that she was abandoned or left at Hawaiki

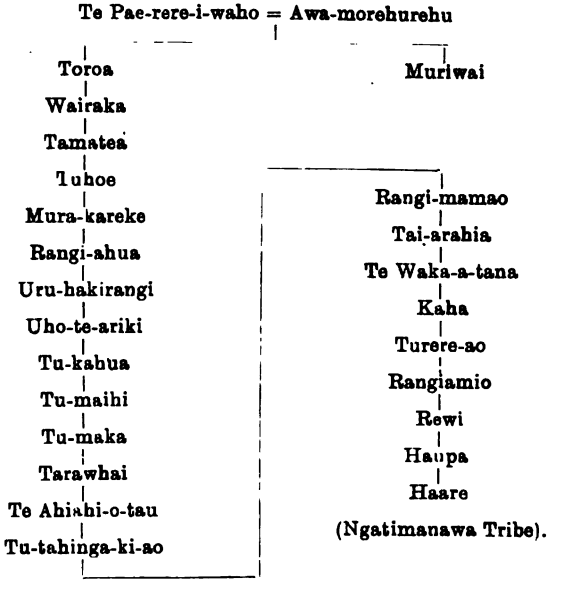
with Hoaki. But her crew returned here on the "Matatua" canoe, and, so say some, also on the "Takitumu," which latter is doubtful. If the "Takitumu" canoe was contemporary with "Horouta," then she obtained some six generations or so before the time of Tama-ki-hikurangi and "Te Aratawhao." Ngatiawa state that on the arrival of "Te Aratawhao" at Hawaiki the people there were attracted by the accounts of New Zealand, hence many of them migrated hither, bringing with them the crew of the "Aratawhao." This migration was the historic one of "Te Arawa," "Tainui," "Aotea," "Matatua," and other vessels, and took place about the fourteenth century. Some assert that the crew of the "Aratawhao" made a prolonged stay at Hawaiki prior to returning to Whakatane. If Irakewa visited New Zealand before "Matatua" arrived, then he must have come after Taukata arrived, for it was the latter's visit here that caused the excitement about the *kumara*. The "Matatua" canoe was constructed expressly for the purpose of bringing a number of Polynesian migrants to New Zealand, as also the "Aratawhao" crew. It also brought seed *kumara* to Whakatane, and this was the undoing of our old friend Taukata; for when the men of Whakatane obtained the seed *kumara* at the hands of their Hawaikian friends, the latter said to them, "When you arrive home be careful in the storing of your seed, and when it is placed in the store, then conduct our friend Taukata into the storehouse, and there slay him, even that his blood be spilt within, and do you also sprinkle his blood upon the door, *kei hoki mai te kura ki Hawaiki*, lest the *mauri* of the *kumara* return to Hawaiki." Even so was Taukata, the bold Polynesian voyager, slain as a sacred human sacrifice to the gods of the Maori. And for many years after the skull of Taukata was brought from the cave in which it was kept, in the planting season, and deposited on the edge of the cultivation, and in each eye-socket was placed a seed *kumara*, while the officiating priest performed certain rites in order to cause the crop to be a plentiful one, and to prevent the *mauri*—that is to say, the vitality, or vital essence, or fertility—of the *kumara* from returning to Hawaiki.

Tama-ki-hikurangi acted as pilot for the "Matatua" canoe on the voyage from Hawaiki to Whakatane.

Toroa, the commandant of "Matatua," is said to have married a granddaughter of Rongoatau at Hawaiki, but found another wife when he came to Whakatane.

Rongoatau
|
Tuturu-whatu
|
Iri-a-rangi = Toroa = Te Paerere-i-waho.

But other authorities give—



Now, if, as is stated, Awa-morehurehu was a member of the crew of "Te Aratawhao," and the above is correct, then that crew must have remained at Hawaiki long enough for Awa to marry and raise children to man's estate. But of the "Matatua" canoe and its story we have but little now to do, and will leave it for a future paper. Sufficient is it for this paper to place on record a most remarkable voyage made by the original people of New Zealand, members of a race of bold sea-rovers who were making voyages of thousands of miles across the Pacific at a time when our forefathers dared not lose sight of land.

Art. III.—*On Maori Dredges* (Roukakahi *and* Hao).

By Alfred K. Newman.

[*Read before the Wellington Philosophical Society, 22nd November,* 1904.]

Plates I. and II.

I exhibit these two dredges before the Philosophical Society, and have prepared this paper, because all ancient Maori works tend to become fewer, and, as some will perish altogether, it is well they should, ere too late, be photographed and described.

All this is the more necessary because the Maori of to-day knows little of his forefathers' arts—knows very often neither their names nor their uses. Indeed, curio-hunters have bought so largely that the Maoris themselves retain scarcely any of these old works, and to-day, at the close of 1904, the only chance for a new collector is to ransack European shops, and occasionally buy from a European collector. The few Englishmen who really have a great knowledge of these things are dying out, and several are letting their knowledge die with them. Ere it is lost I put into this paper what I have learnt about these dredges.

RARITY.

Looking over Edge Partington's and other works describing Polynesia, I find no trace of these dredges outside New Zealand. They were invented by the Maoris, and were theirs solely, their Polynesian kinsfolk knowing nothing of them. *Roukakahi*, having been invented by Maoris, cannot be of an older date than the advent of the canoes from Hawaiki, and doubtless were not invented till long after—probably were invented within the last two centuries. In New Zealand to-day they are amongst the rarest of their works of art. I got one about two months ago, and, strange to say, another about a week later. There is one in the British Museum figured in Partington's book, one in the Christchurch Museum, and two in the Auckland Museum; there are two in a shop, and Mr. Hamilton and Mr. Turnbull, in their fine collections, have one each; the Wellington Museum also owns one: making the total number, including mine, eleven. Of course there are others, but nevertheless they are rare.

As Maoris now get plenty of animal food, and as their numbers are smaller, the need for getting large supplies of fresh-water mussels lessens year by year: there are ample in shallow waters. Elsdon Best, that splendid worker and authority upon all Maori works, says that shellfish in Tuhoeland are not now eaten. These dredges, therefore, are now never used, and no new dredges are made. After a diligent search amongst the Maori literature of Angas, Colenso, White, Hamilton, &c., I have found only very brief stray references to them. This is an attempt to detail their history, their structure, and their uses, and these are the first ever exhibited before this society.

NAME.

The Maoris had two sorts of dredges, one with teeth, the other without. The rake dredges were used in the shallow lakes abounding in the hot-lakes district: these were called *roukakahi*. The plain or toothless dredges were employed in Lake Taupo, and were used to catch crayfish (*koura*). Best says

another name for *roukakah* was *heki*. Tregear's Dictionary gives *rou*, "a long stick to reach anything with, to reach by means of a long pole, or to move or stir about with a pole." As these dredges were always tied to long poles, and by these means were rolled or stirred about at the bottom of the lake to collect the shell-fish, the origin of the word *roukakahi* is clear. *Kakahi* is the common fresh-water shell-fish (*Unio*) lying partly imbedded in the lacustrine mud. Every dredge consisted of a long pole, a *rou*, a dredge, and a net and sinker. The stone sinker was called *mahikea*, the rope *kaha*, and the flax-net *rori*. *Roukakahi* were also used to catch crayfish.

The *hao* was the toothless dredge used for crayfish-gathering in the waters of Lake Taupo. Its frame was stouter, it was uncarved, and less care was bestowed on its construction. *Hao*, in Maori, means "to draw round, or to collect fish, as in a net."

I have an extremely rare Maori curio, shaped like a marlin-spike, called *ahao*. At the base a hole was bored in it, and it was used to pass strings through the gills of dead sharks, &c., to collect them together.

In Tuhoeland Best says Maoris fished sometimes for *koura* with a net drawn along the bottom, but without a dredge attached, and such nets were called *paepae*. In the Horowhenua Lake to-day Maoris fish for *kakahi* with a net like a *paepae*, but never trouble to create a dredge.

I happened to show this carved *roukakahi* to Major Whitney, a sportsman of the widest culture, and the moment he saw it he exclaimed, "An English oyster-catcher." As a boy he had seen oyster-dredges, made of iron, exactly similar in make and principle—a triangle with raking teeth, and holes as seen in this one, and notches to tie on the net-strings. He knew all about this dredge directly he saw it. As dredges were used by Maoris long before Captain Cook's arrival, it is clear the Maori and the Severn fisher evolved an almost similar instrument to meet almost identical needs. In Cornwall similar toothed dredges were called "rake dredges."

Distribution and Uses.

My black *roukakahi* was bought from a chief of the Ngatirangiwewehi Tribe, of the Awahou Pa, a few miles from Rotorua. The other, with the net, was owned by a member of another hapu of the great Arawa Tribe.

Roukakahis were used in shallow lakes, but never in rivers or on the sea-shore. Apparently they did not exist south of Lake Taupo, where the *hao* was used in the shallower parts about Toka-anu. They were in use in Rotorua and adjacent lakes, and scarcely at all elsewhere. From all time Maoris, and especi-

ally Maori women, have collected shell-fish by wading into water as deep as they could go, but as they found the *kakahi* lived in great numbers in the deeper waters they invented this clever and complex machinery for gathering them at greater depths, and these dredges served admirably. The limit of depth at which they could be used was bounded by the length of the tallest pole they could find in the adjacent forest.

When Maoris fished with a *roukakahi* they acted as follows: A Maori stood up in the stern of the canoe, and this *roukakahi* was slipped over the side with its attached net, and tied to it was a sinker of volcanic stones. Some dredges had three sinkers. Attached to the apex of the triangle, firmly bound to it by strong flax string, was a long pole, the one end at the apex, the other in the hands of the fisher. The Maori felt about until the dredge touched bottom, then he began to work. He rolled the stick about from side to side, and, of course, the dredge at the bottom, and so he went on dragging the dredge and the net, now fast filling with shell-fish. This was very laborious and tiring work. Mr. J. T. Smith says in a previous article in the Transactions that this work was hard and fatiguing, and an old Maori couplet praised a Maori who worked long and industriously at it as being a particularly good husband—a great provider of shell-fish. Colenso, in his collection of Maori proverbs, mentions "*Taane roukakahi moea*," which he translates, "The husband who is dexterous at getting shell-fish in deep water will find a loving wife." Strange to say, Colenso adds in his comment that the work of gathering shell-fish in deep water was very arduous, and writes as though he had never seen or heard of these dredges. Having *roukakahi*-ed one patch of lake-bottom, the canoe was paddled to fresh ground, and the work began anew.

On Lake Taupo, where fresh-water crayfish were caught, the method of using a toothless dredge, or *hao*, was slightly different. My friend Mr. L. Grace tells me that the canoe was fastened to a tree on the bank, and then rowed out to the full length of a many-fathomed rope. The *hao* was put overboard, but not worked from side to side in the same way as a *roukakahi*; the long pole was so held that the apex and part of the dredge were a little distance above the lake-floor. In this way the hopping crayfish were enfolded in the net. The Maori in the bow slowly pulled the canoe over the lake's surface till it got to the tree anchor, whilst the Maori in the stern held the dredge in proper position to catch the *koura*. The upper lid of the net was kept open by means of a string tied to it and the long pole, and thus it was kept open wide enough to engulf the *koura*. The apex of the dredge was held a few inches from the bottom in order better to catch the jumping crayfish.

A *roukakahi* thus richly carved, with its attendant implements, was a work of toil and care and art. In bygone times it was highly prized, and was the property of a *rangatira*. When out of use it was hung up carefully high in the whare, where smoke and soot have given this one its rich deep-black colour. Nets wore out quicker than the dredges, but these were easily replaced: one dredge would serve for whole generations of nets.

Description of Dredge.

Every dredge consisted of a long pole, the dredge proper, a net, and sinker or sinkers to complete the outfit. Any rough-cut pole out of the bush was used: this was not carved. Dredges were usually made out of *manuka*, and of two pieces of wood. They were never carved out of a solid block of wood. In shape each dredge was an isosceles triangle — a long base and two short sides. My ancient black one is 36 in. over all at the base, and the space between the sides at the base is 29 in.; from base to apex is 15 in. The other dredge, with net attached, and uncarved, is 41 in. at the base, and inside is 33 in.; distance from base to apex, 11 in. At each of the basal angles the timber of the sides was thick and wide, but the sides tapered off to a blunt point. These sides never met at the apex: they were cut 1 in. or 1½ in. apart there, and their ends bored with two holes each. These holes were tied together with many folds of strong flax twine bridging the gap. To these collected strands of tough twine the end of the pole was tied, and thus a sort of hinge was made and freer play was allowed between the pole and dredge. Along the base was studded a row of teeth. These teeth consisted of rounded black hard pegs, each about 6 in. long. They were most tightly bound to the base, and pointed forward, but not in the same plane as the dredge, but at such an angle as would dip slightly into the mud and rake up the shells into the net. In one the teeth are twenty-four in number. Starting from the left-hand corner there are eight teeth; then comes down the upright beam, then eight more teeth; the upright beam again, and eight more in the third space. These pegs were tied in the strongest possible manner to the base by flax and other harder plants. The dredge, its timbers all blackened by lake mud and *whare* smoke, with its beautiful carvings, thus makes a most charming specimen of ancient Maori art.

How the Dredge is strengthened.

On reference to the photographs it will be seen that the dredge is greatly strengthened by two beams extending at right angles from the base to the sides. The long base was strengthened by these beams. The base between the angles was divided into

thirds, and from the junction of each third ascended a beam. Each beam was a hook, and the hook embraced the base, and by its projection formed an additional but shorter tooth. Each beam was about ¾ in. wide. For about its final inch it laid flat against the side, and was tightly fastened by passing plaited flax through a hole in the side. Near where each upright beam touches the side ran a beam parallel with the base, and crossing the upright beams at right angles. This beam reached from side to side, being firmly lashed to each side and to each beam the three beams making the dredge far stronger.

THE CARVED FIGURES ON THE DREDGE.

My ancient Maori dredge and all the older ones were adorned with carvings of human figures, almost certainly in all cases representing a deity. Both the ends of the sides near where the directing-pole was tied carry a carved figure, the head of a man. On either side of the base is carved the figures such as one sees on a greenstone *heitiki*. The carving on this dredge is very clean, and a Maori expert declares it to be very fine and old.

Europeans often think these carved figures were placed there for mere decoration, and because the Maori loved art and liked to have pretty things about him. In the vast majority of Maori carvings, however, they were done not for decorative but for religious purposes. Figures on bone and greenstone *tikis* always depicted an ancient god or a revered half-deified ancestor. An ancient Maori's whole life was immersed in religion and religious ceremonies. If he went to war, or got married, or was baptized, or planted a *kumara*, or went rat-catching or fishing, he or his priests performed religious rites and chanted figures. He scarcely made any move without performing some act of religion—to give him success or to avert disasters. The old Maori world was peopled with gods whom he did not love, but whom he feared. His gods were nearly all cruel gods. These *roukakahi* carvings, therefore, were representations of some ancient Maori god or gods. In the "Transactions of the New Zealand Institute" Best gives a hymn sung by the Maoris when about to eat the shell-fish dredged by the *roukakahi*. It was sung when the shells were brought to the feasts—"*Tane roukakahi e*"—and thanks Tane for giving such a liberal supply of food. Best's translation reminds one of the harvest hymn—

> Lord of the harvest, once again
> We thank thee for the ripened grain.

My more modern dredge with net attached has no carving. The old one was carved when Maoris began a fishing excursion with religious rites: he took a dredge with these half-human,

half-divine figures carved—carried his god or gods with him. The modern Maori, performing no ancient rites, never bothers about carving semi-divine figures—hence this modern dredge is quite plain. The old dredges exhibit kindred carvings of deities, and probably, as Tane was addressed in Best's hymn, these figures are images of that great god.

The Net.

The net (*rori*) is a sort of basket: it is 31 in. from top to bottom, and averages from side to side 33 in. Its meshes are diamond-shaped, of knotted flax; each open space is 1½ in. long by 1 in. wide; the meshes are wide enough to let all the mud run away, but fine enough to hold the shell-fish. This net is a rectangular parallelogram: it has length and breadth, but has no sides for its thickness. The under side is tied closely along the under side of the dredge along its whole length. The upper side is tied to the holes in the dredge's sides. The upper side of the net of the *hao* was tied by a string to the pole about 2 ft. above its attachment to the *hao*: in this way the mouth of the net was kept open some inches above the *hao*, so that even if an affrighted *koura* tried to jump above the approaching *hao* it would not jump high enough to clear the net, but fall into it.

The Sinker.

A necessary part of the *roukakahi* was a sinker: some had three small sinkers instead of one large one. Occasionally sinkers made of soft stone were slightly carved. The sinker photographed is a large, round, heavy stone. All round it is a shallow groove for the rope to lie in, and another runs round at right angles to the first. Each groove is 24 in. in length. The base of the sinker, instead of being rounded like the rest, has been cut off smoothly, and thus a broad, flat surface lies in the lake-mud. When three smaller sinkers were used one was attached to each angle of the dredge.

Art. IV.—*The Early History of the Morioris.*

By A. Shand, Chatham Islands.

Communicated by Professor H. B. Kirk.

[*Read before the Wellington Philosophical Society, 3rd August*, 1904.]

The predisposing cause of the advent of the Moriori people to the Chatham Islands from their ancestral homes in Polynesia, as stated by themselves, was war and fighting—or, as they phrase it, "the trouble in Hawaiki." This is detailed by them in their

legends similarly as with their Maori brethren, of whom there appears little doubt they formed a part, but from whom they had been isolated for a very long period. That this isolation was the case is shown by their genealogy, counting from the arrival of the "Rangimata" canoe, which brought their ancestors twenty-seven generations ago, down to the reciter, and from him until the present generation three more may be added. Estimating a generation at twenty-five years, this makes considerably over seven hundred years. That they were an offshoot or part of the same Polynesian race will, I think, be quite apparent to any one studying the structure of their language, although disguised in a measure by their peculiar pronunciation—examples of which will be found to those taking an interest in such studies in papers contributed by me some years ago to the pages of the "Polynesian Journal."

In the collection of legends and *karakias* (incantations) there recorded will be seen the close connection with their Maori brethren, together with the retention of many words common to the Rarotongan branch of the race, and common, no doubt, at a remote period to all the race.

This account ought more strictly to refer to the Morioris alone, but, through their conquest by the Maoris, with their long residence together and intermixture, it has been found necessary to treat of both in order to show how they were related, together with the causes which brought the Maoris to the Chathams.

According to Maori tradition and evidence there appears little doubt that New Zealand prior to the arrival of the so-called "historic canoes," "Tainui," "Te Arawa," &c., was peopled by a former migration of a section of the same race, many of whom, as related by the second migration, were killed by them, and no doubt disposed of in orthodox Maori fashion. Whether the Morioris were a branch of this original migration or not is difficult to decide, as also the question whether their last battle, as recorded by themselves, took place in the north of New Zealand or in Hawaiki. One circumstance: The names of places mentioned in their last fight, the "One" (sand-beach) of Whangapatiki, of which they state Tauranga was one headland and Tapuika the other, together with other names of places, are all common about Tauranga—which, however, may be merely a coincidence; but the names retained by them in their traditions of such trees as puriri, pohutukawa, kauri, and others (strictly northern trees, but unknown in the Chathams), indicate a previous knowledge of those parts.

But, assuming their genealogy to be correct, there remains a gap of years to be filled up prior to the "Tainui" migration.

showing apparently that they were antecedent to that migration. In connection with this it may be worthy of remark that during the stay of the Hauhau prisoners at the Chathams many of the last batch (called "No. 4") came from Tarawera, Te Whaiti, and thereabouts, while several of their women were almost the counterpart of the Moriori in physique, but more particularly noticeable in the same kind of frizzy semi-Fijian style of hair, so much so that a Maori friend remarked "They are exactly like Moriori women"—quite different from the ordinary Maori women of his tribe the Ngatiawa.

With regard to the term "*waka*," or canoe as we call it, the term, having in view the present-day build of such, is certainly a misnomer, and the word "vessel" would be more appropriate, for no canoe of the present type could, except under the most exceptional circumstances, ever have crossed the long stretch of ocean between Rarotonga and New Zealand, or New Zealand and Chatham Islands, consequently it may be accepted as an impossibility. The word "*waka*" with Maoris and Morioris embraced all kinds and sizes of canoes, and it is quite certain that the vessels in which they made their long Pacific voyages were not of the present type.

The Morioris state that far back in their genealogy, in the time of Te Akaroroa, there came one discoverer named Kahu to the Chatham Islands, but could give no other name to his vessel than "Kahu's canoe." This Akaroroa existed, assuming that the prior part of the genealogy is continuous, before the time of the "Rangimata" *heke* (migration)—a long time, many generations, before the "Rangimata" people arrived—so far back indeed that they were unable to give more than meagre particulars about him, or where they derived their information concerning him. They state that he touched first at a place on the south-west corner of the island named Tuku—or, in full, Tuku-a-Tamatea, such being the name of Kahu's lieutenant. Leaving him in charge of the vessel at Tuku, Kahu set out on a journey of discovery—whether with or without companions does not appear—and followed the south line of the cliffs, which is rough enough now, but then, before the era of fires, for a considerable distance must have been impassable. They narrate that at some parts of his journey he could sleep, but at others not. Proceeding northward, following the coast-line of Hanson Bay, he journeyed round by the north coast to Whangaroa, at the north-west corner of the island, where he was stopped, it is alleged, by finding the sea breaking through a channel or strait from the north coast into Petre Bay, thereby making a separate island of the north-west corner.

When Kahu arrived he found the island *e kauteretere ana*

(drifting or floating), as they express it, and joined some parts together, and separated or left separate others—presumably this gaping waterway—and thence signalled, by raising a fire, for his vessel to come to him, which she did, to Whangaroa or Tei-kohuru (quiet or still tide). Thence he departed to Waitangi, or Waiteki (its old name), where he dwelt awhile and planted his kumara, which would not grow owing to the coldness of the climate; after which, not liking the land, which he called *e whenu rei* (a watery land), he returned to Hawaiki.

How the latter part of the story originated, excepting by way of embellishing, it is difficult to imagine, unless at that time there was something in the geologic appearance of the country which appeared to require notice, contrary to what appears at present—similarly, perhaps, to the Maori legend of Wellington Harbour, which at one time was an inland lake in which dwelt two *tipuas* (monsters), Ngake and Whataitai, who, jointly impelled by a sudden desire to burst out seaward, made respectively —Ngake for the present entrance to the harbour, which he duly burst open, making the present passage; and Whataitai for Evans Bay, where, failing to find an exit, he ran his nose incontinently ashore; thence, however, assuming the form of a bird, he went up to the top of Tangi-te-keo, whence he screeches down on to the Wellington waters. Let the unbeliever disbelieve this if he pleases!

Kahu further was said to have planted a certain kind of fern-root alleged to have been peculiar to one part of Kaingaroa Harbour, and called after him "Kahu's fern-root" (*ko te haruhe o Kahu*). Whether any of Kahu's crew remained on the island or not is unknown to tradition, but presumably either they or some other migration did, as the "Rangimata" migration are very clear regarding the fact of finding people on the island when they arrived, whom they termed "Te Hamata"; and bones alleged to have been theirs, of huge size, especially thigh-bones, were common at one place swept away by the Awapatiki.

Prior to the arrival of "Rangimata," it is said, two of the migrants who came in her, named Maruroa and Kananga, went to the land of Irea and Tahiri, where they were alleged to have acquired the knowledge of the months, and information regarding Rekohu (Chatham Islands)—apparently sailing directions, and the information where to find them. There is nothing, however, to show where this land of Irea and Tahiri was, apart from the narrative, which indicated that a knowledge existed of it somewhere of which the migrants got the benefit.

The migration took place, as before stated, owing to "troubles" among themselves—according to their story, the killing by Tamate-kohuruhuru of his *whai-tipanga* (sweetheart) Papa, who was

of the Rauru Tribe, he being of the Wheteina—although from the subsequent story it would appear that these distinctions were somewhat arbitrary, as Tumoana, on hearing of Papa's murder from his son Tama, tells him, " To-morrow we shall be exterminated by your parent Horopapa " (her father). The cause of Papa's death, it may be added, was that she had spoken disparagingly of Tama-te-kohuruhuru, saying that he was lacking in manhood, the disgrace of which enraged him so that he killed her in revenge, resulting in a war between the two tribes, in which the Rauru proved victorious, killing and burning Tama and his people in their house, or houses, Tumoana alone appearing to escape, as he fought afterwards with the Rauru.

Meanwhile things went so hard with the Wheteina, and other tribes their allies, that they commenced building *wakas*, or vessels, to seek safety, and it was at this time that " Rangimata " and " Rangihoua " were made and launched, and when on the sea before departing they heard the voice of Kirika, elder sister of Tumoana, performing an incantation over Tumoana's *maro*, or war-girdle, preparing to do battle. What was the result they did not appear to know, leaving, as they phrased it, to " circle or compass round the crown of the land and ocean " to seek a new home for themselves.

Whether the two vessels kept together or not is uncertain, but both arrived on the north coast. " Rangihoua," with her crew sea-beaten, starving, and dying with thirst, was beached, or more probably driven on shore, at a rocky place called Okahu, where most of them were drowned, others dying as they landed. One (a priest) carrying the image of his god drank at a small stream, dying as he drank—caused, they allege, by the desecration of the god in so doing. From certain names mentioned it seemed that some escaped, but no *karakias* (incantations) were brought, they say, in " Rangihoua "—apparently all who knew them were dead. The season of their arrival, too, was most unfortunate, coming as they did in *Rongo* (July), the most boisterous of the winter months. It is stated that " Rangihoua " was not properly completed owing to the haste of departure, hence they allege her misfortunes. Being the beaten side, no doubt there was little time to spare in preparation.

" Rangimata," her consort, had better luck, as she appeared to have arrived, according to the story, at the north-east end of the island, planting, they allege, the karaka-berry at a place called Wairarapa. Her crew landed at various parts of the island, where they saw the original inhabitants, and conversed with them, who contrasted the warmth of the garments they themselves wore (fur-seal skins) with those of the *heke*—from which it would appear that they were able to understand one

another; and they gave the names of the chief men. Ultimately they landed at the Awapatiki—the mouth of the Whanga Lagoon—closed at the time, but ready to burst out, as it was wont to do unless opened at periodical intervals. Having landed, they proceeded to drag "Rangimata" ashore to get her into the Whanga, but in so doing her weight made a furrow in the sand, forming a channel for the lake, which, bursting forth in resistless force, wrecked "Rangimata." There is a limestone rocky islet, Motuhinahina, in the Whanga, the jagged points of which represent "Rangimata's" crew.

Whether this happened before or after the wreck of "Rangimata" was not stated, but probably before they met the autochthones, Marupuku and his people, with whom they conversed, asking them if the multitudes of eels stranded in the shoal water and dry sand were not firewood. To which question Marupuku and his people replied sagely that it was food. What appeared, however, to have a greater semblance of reality was that the *heke* (migrants) proceeded to set up a post to indicate the taking possession of the land. This, being perceived by Te Hamata, was summarily pulled up by them, after which the newcomers camped at a place called Poretu, about a mile to the north of the mouth, from which they ultimately dispersed and went to Rangatira, settled, and spread over the island.

From all that has been stated, assuming the main facts to be correct, and that the "Rangimata" people were able to converse with the *tangata hunu* or autochthones, apparently they were a section of the same race, who, once located in the island, through the lack of suitable timber could not construct anything fit for a long voyage.

Beyond this little incident nothing further is recorded in the shape of friction with "Rangimata's" people, who dwelt peacefully in the islands until the arrival of Moe, a descendant of, or a son of, Horopapa, who when "Rangimata" and "Rangihoua" left was only a stripling, but on arrival at Rekohu had become bald—showing that a considerable time had elapsed, probably twenty years. Moe's tribe was the Rauru, and his canoe or vessel was called "Oropuke." She was afterwards wrecked, it is said, at a place of the same name at the south-east cliffs of Pitt Strait, extending inland to Trig. Station I. and its vicinity.

Once more meeting their old enemies, after a time peace was broken by one of the Wheteina killing and eating part of one of Moe's people, upon which Moe retaliated by killing the aggressor, with others, at Rangitihi. Then, coming on to Moreroa, Moe proceeded to attack them there, but it is said that in some way they were hidden and smuggled away by one Nunuku, who appeared to be a relative of Moe's as well, of whom more anon. How it

happened does not appear clearly, but subsequently Moe, with his people, went to Pitt Island (Rangiauria), where the Makas and Harua people insulted him by cursing him, upon which he attacked them, killing and eating several of them. Later on, however, they retaliated by burning Moe and his people in their houses at night. This was stated by some to be incorrect, but the statement was clear and distinct, while the fact that Moe's name no longer appeared in evidence after that appears to substantiate the story of his death. In commemoration of his doings there are two Umu-a-moe, one on Chatham and one on Pitt Island, while his spear is commemorated by a long volcanic dyke of rock running into the Whanga Lagoon, called Ko Tao-a-moe (Moe's spear).

But to revert to Nunuku, who was said to be a *tipuna* (ancestor) of Moe's, and, from the action he took, quite a unique personage. When Moe and party came to attack the Moreroa people, by some means or other he managed to help them in eluding Moe, who would not harm him. The story says that he smuggled them through a cave under the Moreroa cliffs (of limestone formation) on the Whanga shore, in which he is said to have dwelt, and which is called after him Tehana-a-nunuku (Nunuku's cave). Through this cave it was alleged there was a passage underground of about two miles, which had its exit at Tauarewa, in Petre Bay, through which the Moreroa escaped. Regarding the cave, there was a pool of water in front which was stated to be of recent occurrence, and that it was dry and had been slept in formerly, but beyond the immediate circumference of the cave there did not appear to be any passage, while on the Tauarewa side there is no indication whatever of a passage or exit—if there was one it must now be covered up with sand. Also, there was a flat stone, said to be the door of the cave, which somehow disappeared or was broken, and could not be found, although well known to the Morioris.

But the unique and historical fact that remained was that Nunuku about this time proclaimed a law which was honoured and kept until the Maori invasion, and which in fact is still observed, "*Ko ro patu tangata, me tapu to-ake*" (Manslaying must cease henceforth for ever). Further, that when feelings or honour were outraged by insult or otherwise they might have an encounter with their *tupuraus* (a long pole or kind of quarter-staff, which they used in their so-called fights or *tau taua*). After joining issue, the first blow which made an abrasion of the skin or drew blood ended the fray, the injured or wounded party exclaiming "*E ka pakaru tange nei upoko*" (O, my head is broken); although it did not appear to prevent the injured warrior at a future time returning to obtain in like manner

satisfaction for his "broken head." In connection, however, with this they kept up their old-time war-ceremonies, reciting numberless *karakias* as for a real fight or battle.

Their chief causes of quarrel were curses and insulting and derisive songs at one another's women. Unlike the Maoris, they had no land questions to form the basis of a quarrel, consequently they were never serious. One or two instances are recorded in which the Karewa Morioris seized and took captive for a short time the women of the north-east district, but they returned them shortly after to their homes. Whether any were killed at such times by accident appears uncertain, although there was an indistinct story of such occurring, but any approach to anything of the kind was frowned at as "contrary to the laws of our ancestors."

Thus time went on in successive generations until the arrival of Europeans and the discovery of the group by Lieutenant Broughton, when he landed at Kaingaroa Harbour, or Skirmish Bay, as he named it, where the Morioris of the place came round in wondering amazement to ascertain what these strange creatures were. Noticing the sailors smoking, they remarked "See Mauhika's fire proceeding from their throats!" The rigging of the vessel they likened to *kupenga* (nets), and so forth, with many amusing remarks. The sex of these strange creatures puzzled the natives, and, seeing the visitors were friendly, they touched and handled them. Ultimately some concluded that they were women, while some of the bolder spirits attempted to take hold of them and drag them off to their homes in the bush above the sea-beach. In order, apparently, to put a stop to this the sailors fired to alarm them, on which they remarked, "Hear the crack of the kelp of their god Hauoro!" alluding to the report made by thrashing long arms of bull-kelp on a sea-beach. Then, seeing another party coming up from the east end of the harbour, the sailors fired, killing and wounding some of the Morioris, which scared them, and they fled into the bush. Subsequently the Morioris relate that they thrashed severely those who took part in and caused the mishap to the strangers. It appeared also that some had remonstrated with the others regarding their behaviour to the strangers. Later on a boat came ashore and left some beads and other things as gifts, which the natives took only when the strangers had departed. This is the gist of the Moriori account, which appears to coincide very closely with that of Lieutenant Broughton. They add that the time of year when this happened was that of the maturity of the young of the sea-bird *kukuri*—November as stated by Lieutenant Broughton.

No further intercourse occurred with Europeans until the

arrival of sealers and whalers from Sydney in the early thirties, when they landed in some places and dwelt ashore among the Morioris, but bringing the usual concomitants in the shape of diseases. Some of these whalers, coming from New Zealand in the first instance, shipped Maoris as hands, among whom, with others, there happened to be one Pakiwhara, a Ngatitama, and Ropata Tama-i-hengia, a well-known chief of the Ngatitoa Tribe. The latter dwelt with the Morioris at Wharekauri, the name of a small *kainga* on the north coast. Not understanding their language sufficiently, on his return to Wellington he failed to give the proper name of the island Rekohu, but spoke of it as "Wharekauri," the name it has been called by the Maoris ever since.

Pakiwhara, however, was the first to convey the intelligence of the Chatham Islands to the Ngatitama and Ngatimutunga dwelling in Wellington. As far as is known, he did not leave his vessel and dwell ashore, but evidently he saw a good deal of them. On arriving at Wellington, as told by one of the old men describing his adventures, he said, "To the eastward from this there lies a land—it is a *whenua kai* (land of food), with lots of sea- and shell-fish of many kinds, and multitudes of eels; also it is a land of *huahua*—describing the way the sea-birds at that time burrowed all over the high land and peaty points of the island—"also that the *toroas* (albatros) built on the outlying islands in great numbers." This excited them very much, for *huahua* of all kinds was a much-prized delicacy with the Maoris. Moreover, he added—of which they took special note—"They are an inoffensive race, and do not fight, or understand the use of weapons." One thing, however, which he apparently failed to inform his friends of was the limited extent of the islands. However that might be, the story told so excited them that both Ngatimutunga and Ngatitama held meetings to devise means to get this desirable land of which they had heard—the former at Kumutoto (Lambton Quay) and Te Aro, and the latter at Raurimu (Thorndon)—and each made their plans to seize and appropriate the islands. This they did by seizing the brig "Rodney," having first induced the captain to cross to Somes Island, where they intimated to him, without using any personal violence, that he was their prisoner, and must take them to the Chathams, and that they would pay him well in *muka* (scraped flax) and pigs, with some muskets thrown in. Meanwhile another party captured the vessel, but roughly treated the mate Ferguson (well known afterwards in Wellington), injuring his thigh by throwing him on the deck. Finding himself helpless the captain reluctantly consented, and took them in two batches to the Chathams.

Before going farther, however, it may be interesting to show how the Ngatiawa people came to Wellington and its vicinity, and the operating causes thereof. In this case the great disturbing element was the advent of Europeans with firearms, which completely changed the existing order of things, especially in the Maori world: those tribes that managed to obtain arms before their neighbours were enabled to gratify their revenge on them with a maximum of injury to their enemies and a minimum of loss to themselves. Thus the Ngapuhi, being first to obtain firearms in quantity, were able to raid and devastate neighbouring tribes who till then were quite able to hold their own against them. Obtaining a certain quantity of firearms, a war-party was formed of Ngapuhi, Ngatiwhatua, Ngatitoa, and a few others, chiefly impelled by a love of fighting and renown, coupled with the very agreeable feeling that with firearms on their side their adversaries would be defeated. Concentrating at Kawhia, they coasted along to Taranaki, where they were entertained. They then continued their journey southward to Whenuakura, where they attacked and killed people, and so on to Wellington, where they created much havoc with the Ngati-ira in the Hutt River. (A full account of this part of the raid has been contributed by Mr. S. Percy Smith to the pages of the "Polynesian Journal.") Among the leaders of the Ngapuhi were Patuone and his brother Tamati Waka Nene, Murupaenga, of Ngatiwhatua, with Te Rauparaha, and others. It was this Tamati Waka Nene who, on seeing vessels off Kapiti Island, suggested to Rauparaha that he should come and occupy Wellington and its vicinity—a recommendation destined to bear fruit afterwards. This expedition, from its length, was called *amio-whenua* (circling round or encompassing the land).

Subsequently, owing to Rauparaha's truculent behaviour in killing his Waikato neighbours, notably several of high rank—the merits of which, however, appear to have been pretty equally divided—they all combined in attacking him and inflicting a defeat. Ultimately Rauparaha only managed to get across the Mokau River with difficulty, being hampered with his womenkind and children, and he and his tribe took refuge with their allies the Ngatitama, but more particularly Ngatimutunga, both large sections of the great Ngatiawa Tribe. His Waikato enemies, however, followed him up later on, with two objects in view: partly to give him and his friends a thrashing, and also to relieve their Ngatimaniapoto friends, who were besieged in Pukerangiora *pa*, inland from Waitara. Arriving at Te Motunui, about half a mile, perhaps, south of the Mimi River, they attacked Rauparaha and his Ngatimutunga allies, but they suffered a crushing defeat, losing most of their leading chiefs.

among whom were Te Hiakai, Hore, Mama te Kanawa, and others, and but for the bravery of Potatau in rallying his people the position would have been much worse.

As illustrating the peculiarities of Maori procedure, and what chiefs of rank might do in such cases, may this incident be narrated: Potatau, to whom Rauparaha was related by consanguinity—a *matau* (parent), a sort of grand-uncle, a few degrees removed perhaps—recognising the dangerous predicament his party were in, suffering from a defeat, with the certainty that the fighting Ngatitama coming from south of Mokau with the morning light would with their victorious enemies converge on and annihilate them, called in the waning light to Rauparaha, "E Raha, he aha to koha ki au?" (O Raha, what is your boon to me?) to which tersely and quickly came the reply, "Go south, you will be safe; go north, and the upper jaw will close on the lower one." Quickly grasping the situation, without another word, and with the ebbing tide, they struck camp, fording or swimming the mouths of the rivers. They forded the Waitara at the mouth, and then proceeded straight inland to their besieged relations in Pukerangiora, where they were safe, and joined in one huge wail over their disaster. Later on, thus reinforced, they returned to Waikato, neither attacking nor being attacked, to croon over their losses, and meditate on revenge for about ten years, in the meantime acquiring many firearms. When they did return they found both Ngatitama and Ngatimutunga, all but a few, gone south; and with the basest ingratitude they attacked and killed the owners of the very *pa* that had protected them, together with hundreds of other *hapus* who crowded in for shelter. Neither did they take the *pa* by assault; but the starving multitudes of outsiders, unable to bring in supplies—the Waikato having come before the crops were gathered in—and being no longer able to bear the strain, foolishly broke out in the day-time, when the Waikato, seeing the cloud of dust raised by the escaping starving multitudes, with fierce yells at once attacked and pursued the flying horde, who, panic-stricken, rushed over a deep ravine and were smothered in hundreds, the stronger ones alone escaping over the squirming and smothering bodies of their friends into the forest beyond. A number, however, who knew the place, escaped by means of an *aka* woodbine, and a tree fallen across the ravine, with which they swung across the chasm, getting away scathless.

Meanwhile Rauparaha, taking the advice of his friend Waka Nene, migrated south with a certain number of Ngatimutunga and others partly related to the Ngatitoa, who went to Kapiti Island and settled there. They did not dare to live on the mainland until later on, when a large body of the Ngatimutunga

arrived, and they were able to occupy Waikanae, Otaki, and the surrounding district.

Prior to the attack on Pukerangiora *pa* several large bodies (*kekes*) of the Ngatiawa, being aware that the Waikatos intended to attack them, migrated to their friends about Waikanae, but the fall of Pukerangiora caused all but a few to leave and join their friends, and the Ngatimutunga and Ngatitama then occupied Wellington, either slaying and driving out the remains of the Ngati-ira people or enslaving them.

At this time, however, Rauparaha, who had raided and defeated the Kaikoura people, proceeded to Kaiapohia, with the evident intention of attacking and enslaving them also, his party meanwhile having, by way of insulting the people of the place and their chief, dug up a petrified corpse of a relative of Te Maiharanui, and, ghoul-like, devoured it. The Ngatitahu having exhausted offers of conciliation, some of the leading chiefs of Ngatitoa who entered the Kaiapohia *pa* were set upon, slain, and duly eaten, including the *ariki* of Ngatitoa—Te Pehi—equally related to Ngatitoa and Ngatiawa. A large party of the latter assisted Rauparaha in the taking of Kaiapohia, after which they returned to their homes.

Meanwhile the Ngatimutunga, who had made up their minds to attack the remaining Ngaitahu and occupy the Middle Island, on hearing the story related of the Chathams changed their minds. They gave up the idea of settling in the Middle Island, and made their canoes up the Hutt River to be shipped to the Chathams instead. Arriving at Whangaroa, the first batch, as soon as they recovered from their trip, set out in all directions to take possession of the island, so that on the arrival of the second shipload the land had all been secured, leaving the second lot to live with their friends. Owing to this dissatisfaction arose, and a number of them arranged with a brig to take them to the Auckland Islands in or about 1843, where most of them stayed till brought back by their friends in the "Lallah Rookh" many years after.

Having taken possession of the island and enslaved the Morioris, the Maoris proceeded at once to plant their potato-seed brought with them, and, not being able to bring any quantity of eating-potatoes, scattered all over the island seeking food, digging fern-root, almost robbing the Morioris of their slender stores of steeped karaka-nuts, compelling them to dig fern-root, catch fish, birds, get firewood, and so forth, of which they themselves received a very scant share.

Finding the treatment they received very bad, the Morioris sometimes ran away, thereby affording the Maoris a pretext to kill them, for which they found many causes. If they did not

work hard enough they were beaten and killed. If a man had a handsome wife she would frequently be taken by her master, and the husband disposed of, particularly if she ran away to him. On one occasion, for no apparent cause but innate savagery, about fifty were roasted in one oven at Te Raki; and on another, at Waitangi, the Ngatitama, for some pretended infringement of *tapu*, or the like, killed the whole lot of their immediate Moriori slaves—men, women, and children—in a most brutal manner, laying them out in a long line extending for several hundreds of yards from the Waitangi River along the sea-beach. Shortly after this massacre a number of the participants in it were killed on board the "Jean Bart," French whaler, which the Morioris looked upon as part retribution for their murdered relations—the only little satisfaction they had. The incident, however, was purely accidental, and arose through a mistaken scare on the part of the captain and French crew, all of whom ultimately lost their lives.

Still unrestful, the Maoris kept "dropping off" and returning to Taranaki till 1868, when all but twenty left for Taranaki and their old homes, from which a few of their descendants have returned from time to time.

The advent of Christianity in their midst was the first alleviation of the lot of the Moriori, when they no longer stood the risk of being killed. In 1855 the arrival of a Resident Magistrate prevented any more ill-treatment as formerly, and they gradually got their freedom, although reluctantly conceded in some cases, but by 1863 it had finally terminated. Finally, in 1870, reserves were allotted to them, which they have occupied ever since, and on which they are fairly comfortable.

ART. V.—*The Early History of the Morioris: with an Abstract of a Moriori Narrative, presented by Captain Gilbert Mair during the Adjourned Discussion on Mr. A. Shand's Paper of the 3rd August*, 1904.

[*Read before the Wellington Philosophical Society, 7th September*, 1904.]

WHEN Papa, the girl wife of Tama-kohuruhuru, was cruelly murdered by him, her father sought for her in vain, but his people were few in number, and he dared not openly accuse her husband's tribe of the offence, though he had strong suspicions. One day he was sitting at the door of his house sorrowing for his daughter when a large *rango* (blue fly) came and rested on

his right hand. He brushed it away repeatedly, but it persisted in coming back, and the fact of it always settling on his right hand denoted that it was not a mere coincidence. Accordingly he addressed the fly, asking "Have you tidings of my lost child?" and the *rango* answered with a loud buzz. "Is she dead?" Another buzz. "Can you lead me to her?" "Buzz, buzz," said the fly. The old man arose and followed it far into the forest till he came to a great pukatea-tree, in a hollow of which lay poor Papa's body. Unable to obtain revenge, which was ever sweet to the ancient Maori, he bethought himself of a very renowned warrior who lived in a distant part of the country, and thither he betook himself at once. Covering himself with a "*kakahu mamae*" (a garment of pain), he sat motionless in the warrior's courtyard for many weary hours to arouse the sympathy of his host, till at last the people of the village, with much ceremony, killed and partly cooked a scraggy dog, which they placed uneviscerated, with the hair on and half-raw, before their guest. Guessing that this apparent want of hospitality was intended as a test of his fortitude, the old man partook of the horrible food, and even made it appear as though he relished the repast. The chief then took him on one side and asked what his trouble was, saying, "You are a brave man, and your cause must indeed be desperate when you can pass through such an ordeal." When the chief was told the particulars of Papa's murder, he informed the father that twice seventy men would start that very night to avenge his wrongs. Tama-te-kohuruhuru's tribe were suddenly attacked and almost exterminated, and forced to migrate, and eventually reached the Chatham Islands. as related by Mr. Shand in his interesting paper.

These minute particulars, preserved through over forty generations, show how ancient traditions are handed down orally by an unlettered people.

THE STORY OF A DYING RACE.

In the year 1852 the whole of the Moriori people assembled at Te Awapatiki, and it was decided to commit to writing some record of their past history, they evidently recognising they were a doomed race. The paper I have the pleasure of reading to you to-night is a literal and simple translation of the account given by the oldest living Morioris gathered together on that memorable occasion—namely, 15th to 29th July of the year mentioned.

Tamahotu begat
Te Arakanini
Rungoiro
Karatapani
Munukupanga
Rakiroa
Te Whakawahine
Hamatirikaka, who begat
Te Timo.

The strangers who came to Wharekauri arrived in three different canoes—namely, "Rangimata," of whom Mawake was the chief; "Rangihoua," whose captain was Honeke; and lastly, "Oropuke," commanded by Moe.

Te Timo married Hinewaro, and begat	Taputake
Tarakauia	Rongomaikahuti
Mahuta	Rumakiwao
Ngaromanga (Ngarauonga ?)	Tamatokote
Kiriwai	Tamatukuora
Poutama	Tamataurua
Hitope	Rongomaikaitoke
Hinanauhanga	Tamanaukahu
Hituranga	Tumukohirangi
Waitamahine	Hinapango
Rongohua	Tamawakoro
Rangitoto	Tamawanauturanga
Tamakope	Tukeoto
Tamawai	Te Wanangamakariri
Maruhokote	Hinengere
Tangorotaurume	Te Rikiwere
Mairu	Taituha
Rongomaiterepu	Wareoro.

The laws, manners, and customs of the Morioris, derived from their ancestors, were very good, benevolence to all men

being the predominant feature. According to their ideas it was very evil to cause the death of another, or to take from a man his land. The various tribes were constantly exchanging visits, and when they occupied each other's lands for a time they never attempted to claim what did not belong to them. The work of the present day would indeed have appeared evil, and quite opposed to their customs. For integrity and uprightness the works of the present generation cannot compare with those of our forbears. Their laws were founded absolutely on justice and truth, and were promulgated by Rangimaiwhenua, ever in ancient days, hence our unwarlike and inoffensive nature, for we followed the teachings of our ancestors, Rongomaipapa, Rongomaiheri, Marupuku, Tutarangimarama, Minoi, Te Timo, Moari, Hamatirikaka, Rakiroa, Tupeneke, Tamangarue, Maruhokote, and Ke. The offspring of those ancestors was Nunuku. He it was who established the law that men should cease to slay one another, at the time when man-eating was prevalent consequent on the coming to these islands of the warrior Moe and his tribe Te Rauru in the canoe "Oropuke." Those people were consumers of human flesh till Moe was slain. Nunuku's descendants multiplied and perpetuated the covenant which he had established, when he said "After me, through all generations, all evil is to be laid aside. Even if blood be shed, no one must be put to death." (*I muri i au ki tera whakapaparanga, ki tera whakapaparanga, ko te patu me taputoake.*) It was from the teachings of Nunuku that peace came upon the land, and the Morioris lived in peace and happiness from the time of their ancestors Matanga, Maruhoanga, and Tamaturangi. They were, moreover, a very sacred people, and obeyed most strictly all the laws relating to *tapu*, &c. For instance, the women and men never ate together, nor would the young people eat in the presence of their *arikis*, or the chiefs with the plebeians. They were very strict in all their religious observances, and prayers were invoked every time food was partaken of.

The food of the Morioris consisted of eels, fish, karaka-berries, birds, fern-root, paua, pipi, porure, whitebait, &c. Thus did these people live from one generation to another. Their god was Hatitimatangi. He appeared in the stormy winds, and his attributes were to cure all ills and heal all diseases that mankind is heir to, and to cast out devils. And so it came to pass in the days of a certain generation, a man was born who was afterwards called Moturangi. He lived at Kaingaroa, and the god Hatitimatangi descended upon this man and abode with him in his dwelling, and revealed to him that shortly a child would be born into the world. Now, the people awaited the fulfilment of this prophecy and the appearance of the promised stranger. And

on a certain day, in the early morning, a woman named Hinekaiwairua went out from the door of her house, and lo! she beheld a young child lying among a heap of firewood, and she pondered within her heart, saying, "Surely this must be the child we were told would appear"; but her hands were not laid upon it. Now, the child was unlike the people of this world—it was altogether different; and the woman Hinekaiwairua ran and hastened to bring some cooked food as a propitiatory offering, lest the apparition disappear, and she fed it with milk from her breast, and it was *rawea* in appearance. When it grew to manhood it was unlike any one else: it had a dark skin (*kiriparauri*), and its face was quite black. The name of Rutowaikura te Wakaputa was bestowed upon it; and on arriving at adult age he took to wife a woman of the land and begat children—Tamahuareka, Tumatakoao, and others.

Up to this period the garments worn by the Morioris were made from flax, but weaving was discontinued, and they clothed themselves with garments made from seal-skins. But if such were not obtainable, then would they plait *mais* from flax, and only the chiefs would wear the seal-skins. Their most highly prized garments, which were also a token of rank, were of two kinds, and called respectively *tahei* and *marohara*. Their ornaments were red feathers, albatross-plumes, sharks' teeth, and *awanga*. The garments mentioned were very finely woven. Only the *tahei* was made from carefully dressed flax, while the *marohara* was composed of undressed flax-leaves, the *tahei* being worn next the skin and the *marohara* over it. The latter was about 5 yards long, and after being wrapped round the body about 2 yards were left, forming an apron or fringe which hung down before and behind and waved to and fro with the wind, and was called *taputapu*. When thus clothed the Morioris adorned their foreheads with red feathers, and wore albatross-plumes at the back of the head. Inner garments of seal-skin or albatross-skin were also worn.

The following are the Moriori names of the months:—

Wairehu	= January	Rongo	= July
Moro	= February	Tahei	= August
Mihitorekawa	= March	Ketaunga	= September
Teupokoteawa	= April	Tauaropoti	= October
Kahu	= May	Wareohe	= November
Tumatehaia	= June	Nuheatakorore	= December.

The names of the moon were as follows:—

Owire	Hoaru	Oika
Otere	Ohua	Korekoretutahi
Oiwata	Maweru	Korekoreturua
Oua	Outua	Korekorewhakapau
Okoro	Ohotu	Tongaroamua
Tamatetutahi	Maori	Tongaroaroto

Tamateturua	Oturu	Tongarakikio
Tamatenui	Rakaunui	Otane
Tamatehopa	Rakaumatohe	Orongomainui
Hohuna	Takirau	Omutu.

The Morioris did not tattoo their faces and bodies like the Maoris.

Such were the modes of clothing and the manner of living adopted by our race up to the eventful year 1836, when the Maoris came from New Zealand. November must have been the month, for we were drinking honey from the flax-flowers when they landed at Whangaroa and built a fort at that harbour. In the month of December they spread all over the island, slaying the people in the north, at Waiteki, Waikanini, and at other places. The footsteps of the invaders were upon all parts of Wharekauri. Then the Morioris assembled at Te Awapatiki. There were gathered together 160 chiefs, beside the multitude of the common people, and a council was held, which included the chiefs from Karewa and Ouenga. It was proposed to make a combined assault on the intruders, and even though many of the Morioris might fall, they would succeed. But neither of the two highest chiefs, Tapata and Torea, would consent to any of the Maoris being slain, as that would be contrary to the covenant of our ancestors, so there was nothing for the people to do but to return, each family to its own place or village. On reaching their homes the enemy were found in possession, and the Morioris were taken prisoners, the women and children were bound, and many of these, together with the men, were killed and eaten, so that the corpses lay scattered in the woods and over the plains. Those who were spared from death were herded like swine, and killed and eaten from year to year, whenever their captors longed for human flesh. Never were the teachings of the Son of Man more gladly welcomed than when the missionaries reached the Wharekauri islands. Then the killing of these hapless people ceased for ever; but they were still treated with great severity, and every indignity cast upon them.

This is the end of this part of the subject. Now will be given the names of all the Morioris, males and females, and the villages where they were living at the time of the invasion. Readers of this document notice crosses put against many names: these marks denote many of those who were killed and eaten.

WAIKERI KAINGA.

Males.

Te Wheneke	Tahonga	Tamaware
Te Rautini	Te Tipuna	Tamatoiwi
Tamatokoto	*Manamau	Tamaokehanga
*Te Hiwarangi	Rauru	Pakihau

Males—continued.

Tatawera
Te Mangatapiri
*Tamaaroaro
Tirakai
Terekohao
*Te Rikipingao
Te Akarangi
Tukoroungota
Marupihinui
*Mawake
Maruhoanga
Tamangakau
Tuaiwi
Puremuheri
Rangikeno
*Putakohao
*Totara
*Te Rikiwanga
Pipi
Tokare

Te Wata
*Tikimatakowae
Tokohu
Hingore
Tamoka
Maitungou
Tiriwanganga
Hiwawa
Haurara
*Hora
Pakia
Tamakarapu
Tokina
Henga
*Tamakahukahu
*Te Rikiwaewae
*Taukina
Hourangi
*Rakeitapu
*Reka

Tamataurewa
Matarangi
Haroa
*Taumatakohiko
*Tuteata
Ruaeo
*Te Ahukino
Tahopuni
Tarukehu
Ramamaioha
Putikimaro
Rahiri
Tamarekoti
*Tangenge
Te Rikirarotonga
*Watitoka
*Te Rengarenga
*Tamauru
Wanga
Pihanga.

These hereunder were all young men at that time (1836):—

Tangitū
Titihorokewa
Rangiwawe
Teitei
Kokori
Poto
Tamakanoi
Rangitipi
Maitokoko
Tapuwaha
Te Aorere
Tukino
Tokararo
Titihorokewa
Titihomeretai
Rerea
Te Orowai
Rangiamio
Tamananao
Kimi
Te Koura
Maitihikitai
Te Rikimuringa
Tangorotiringa
Waturapa
Terikewa
Pungai
Matara
Pakirito
Tiweti
Rangitainihikaka
Haromona

Te Puhango
Rangimene
Tawere
Tamatowaki
Kunene
Te Aeha
Te Hoko
Mairikorangi
Tahipa
Totaranga
Maitoko
Ngatoro
Te Ringa
Tawaki
Tokohume
Manu
Tapuriri
Paonga
Rahiri
Pohue
Taumaire
Ngatauwerowero
Te Moehowarangi
Te Rikimahuta
*Tihangai
Kama
Tumatarau
Maitahuri
Witipene
Turukehu
Munarapa
Apakuku

Ruhinganga
Rangiura
Taipengaru
Potini
Tamariki
Tumarino
Rangiaho
Taura
Te Hopo
Tukoheke
Waiaua
Tureka
Terekewa
Ngakee
Rehua
Tirikanga
Rumaki
Tira
Tamuringa
Paerau
Manawapo
Tamaotea
*Taihakuma
Te Rikitahorangi
*Tamakuatahi
Maitakuware
*Tamaturangaika
Huawanu Tapu
Kirapu
Ranga
Riwai
Honare

Females.

Makutu	Amiria	Ngaria
Witehere	Hinemateo	Pukearenga
Tiomanu	Pungaariki	*Maurea
Punuku	Tumanuka	Hitongoro
Hinemarawara	Puero	Pikia
Hiteke	Kohikohiko	Maiunga
Hinemotahu	Pateau	Motuhanga
Koropo	Perere	Hinemataariari
Hitaparangi	Materenga	Hinewairua
Hinepenui	*Kurapa	*Hinekawairua
Hineroa	Homa	Tumaruhuka
Mootu	Te Atehaiaa	Hinepuanu
Hinemokihau	Takuheituru	Mataki
Hotu	Muhu	Tuhanga
Tutemangamanga	Hitakura	Awarama
Te Angaanga	Hitaiamanono	Piikau
Pukahu	Wakahotu	Hinemotara
Rokaputa	Moearo	Manikiririki
Hinemokai	Hinepuaremaira	Hitowanga
*Rauhimokihi	*Puangina	*Tanehoro
*Mahunua	Manuhorou	*Ngaununa
Roehu	Hinepenenga	Hinepuretangi
Warama	Kehukehu	Hinerauangi
Pitinga	Tiware	Te Hawiki
Ruia	Morari	Tarakoko
*Tataua	Paenga	Tuhuwata
Ropapa	Tauirikura	Koramohora
Rurunui	*Rangaranga	Tirewai
*Taua	*Te Pehe	Huarai
Puhao	*Mokohoaauta	*Muru
*Papatapu	Tumaungawara	Pukorari
Rauti	Pukuhura	Pikau
Puhara	Hinemataranguru	Hinemataeho
Tokorangi	Tuminau	Hiterongoahi
Ngaki	Hara	Mapehu
Hinamotu	Hinanaho	Parairoi
Putara	Maitakoko	Taranaki
Te Pipitona	Puhukei	Hutumanana
Kahukupenga	Puriri	Te Ngaku
Rongorearea	Te Nohoanga	Tukarewae
Hinemariwa	Hinewatuma	Hinekohanga
Makuhano	Tongapoporaro	Nukuhei
Hitongoro	Pahara	Taikehu
Honinoka	Taharoa	Taikehu
Tokerau	Taupua	Horohoro
Romanga	Watiruingatata	Hinepinga
*Punohu	*Monono	*Puroro
Wamaru	Tokorautahiri	Tanakerau

WHAREKAURI AND TUPUANGI VILLAGES.

Males.

Tuwaitoro	Harangi	Rangihitara
Torea	Weta	Makao
Maipuwai	Tautahi	Poika
Rongomai	Tamahokouru	Tamakohirangi
Tangorotehe	Pohauta	Te Tamaiti
Uewēta	Titapu	Rongomaitautere

Males—continued.

*Maikauae	Tapuetahi	Tamakoke
*Taiau	Maitowara	Tawaki
Maikahukura	Maipohue	Tamakahupo
Maiware	Tokopae	Kirihara
Te Rikipenenga	Te Rikipotae	Tamihere
Tamatuarangi	Te Ipanga	Tuetahi
*Te Rikihaware	*Wauhu	Kairakau
Terikote	Tamamotuhanga	Towaitinga
*Tamawairua	Tamakopuhina	Tamakororo
*Tikimanamene	Tamakauri	Tihangai
Tome	*Maitutua	*Turuporo
*Tamakahu	*Tamatehokopa	*Taungoroawatu
Tamatuiho	*Te Rangiurei	*Rangimotira
*Tamatatai	*Makarangi	Mokai
Mapori	Maitokonoho	*Maipohue
Tamakorari	Metaumahi	*Te Ure
Utuha	Kainiwa	Taupaki
*Tahuna	*Maitohokotupaka	*Taupo
Tamorongenge	Tamapuni	*Maiteheuheu
*Maipuki	*Hotu	*Rongomataku
Mahe	Mitoi	Te Moimoi
Kapeka	Te Rikipongi	*Wiri
Morehu	Te Oroa	Morokino
Tamatiaro	Tamakarawao	Maitakowai
Pokare	Te Akauroa	*Waewae
*Maripihinui	Tamakunaki	Taraheni
Tapureho	Tetete	Te Umaroa
Tunu	*Te Rikihokarau	*Maipingoa
*Ta Aokapiti	*Muna	*Tamahiwa
Matataia	Paea	Hokopa
Puroku		

Females.

*Niwa	*Waiarua	Kahutuma
*Mangitaunu	*Titamonomono	Tangireka
Kurahouia	Turikoka	Raauta
Nukutaiho	Pukarewao	Wahuru
Maupuka	Koshi	Waikaiho
Muruhokoroto	Hinehakari	Hinekoromaki
Kohikohi	Parakokopu	Utihau
Tokopua	Tapo	Waturia
Hinekauahi	Kohara	Te Puihi
Hinemarangai	Hinengawari	Muruwaka
Hinamotu	Puroro	Toria
Wairako	Hinaunau	Pinarepe
Hinekikihirangi	Hinengawariwari	Hinepuanga
Ropatapine	Pikihoe	Te Kore
Harihia	Homairetapu	Hinekotipu
Uaua	*Hineporoporo	*Tarauira
*Tamahine	Papa	Tanamatahu
Taramahuta	Hitangi	*Hinemarae
Renga	Mohere	Hitunga
Muruaka	Nukumahuta	Hinemaruhi
Takapou	Pikirunga	*Tuai
*Haunui	*Peketau	*Hinemaui
*Hinemamae	Tikina	Pinerepe
Urukopu	Paterangi	Wakahukuai.

Counted and named by Maitakawa, whose own people the above named were.

OTONGA AND WAITEKI VILLAGES.

Males.

Rangimarama
Mahuta
*Kuruwai
Rongomaitane
Tamatorea
Paporo
*Te Ringata
*Tamaunga
Kawetauru
*Te Rikipuha
*Rangipawenga
Tamihiatai
Tamakopa
*Rongorongoa
Tangarotakawa
Tokehinga
Rangitemene
*Nukungoa
Rangimariu
Rongo
*Te Pouta
*Ranginui
Tahapa
*Morehu
*Te Rikiwero
*Kaukurumariri
*Maenga
*Minoi
*Tahei
Takare
Tangaroahaia
Wakakaranga
Maitupiki
Pakautu
Rakote
Rangiehue
Maitukou
Potihere
Te Rikipo
Motewaewae
Kanohitahore
Tamanauwairua
Terikorororo
Kerea
Pakuku
Tamakopuatai
Rounguruaipango
Tamawawe
Tangungu
Tamahokonukanuka
Tama Iti
Te Kumu
Torea
Te Amoko
Te Rangitake

*Rangihipa
*Rangituataka
Rangitapu
Tahakoi
*Te Mohiwarangi
Tairingipu
Taia
Te Pata
Turipia
Tamakohaia
Te Rikiwananga
Tangitara
Te Aroho
Maitepaki
Tamahokotuane
Upokorua
Rakeiora
*Puhi
Apiiata
Rangiha
*Tapakautu
Tapuhina
*Tapuraumea
*Te Arikitutua
*Rangitoto
*Rongomaiariki
*Te Kiko
*Hape
*Moroiti
Tuhunua
Nukunukuroa
Nganohoanga
Pemua
Takitu
*Terikuao
Rangituputanga
Tamure
Tamakarangi
Tamatehenga
Raka
Pango
Tamatehuru
*Tamanauwenua
*Maui
Tauare
Tamahiwa
Te Rikimaiao
*Toro
Puhiwero
Maikokake
Te Kakariki
Tokoroa
Tamatehokopa
Maitarangi
*Te Rikiture

Tamakau
*Tamatoariki
*Tangotimoto
Kokona
*Pakira
*Tutoaka
Maitongaki
Te Rikitorehu
Rata
*Kokonga
Tururukikiao
Tapukaka
Tokeha
Makawa
Tamakirikiri
*Tamateawangawanga
Turupou
Tangorokama
Tamarara
Hariki
Te Rikimokona-
Kaituha
*Turupou
*Pokai
*Mamaia
*Tamakakenga
*Rangihirara
*Tipehe
*Rangitiamanga
Turuporo
Te Riakiwere
*Rangiwahanga
Tahawera
Maruhote
Rangimanawa
Tamatiu
Tumatahiti
Rongomaitairi
Kahukura
Toroa
Tuhatoti
Matawatu
Tarawa
Terikahurango
*Rangitipu
Taunotu
Tahakoi
Tamaterepu
Tokehoro
Tumokora
Waiorangi
Tamangaio
Te Wetu
Motokarunga
Te Rikimeme

Males—continued.

Te Urukuiwi
Tarakena
*Taputiki
Watiope
Hingimanu
Maitaruke
Apiiata
Tapekepeke
Tamoka
Tuhome
Pakihau
*Kauanga
Rekatea
Te Rikimokawe
Rangiteniwa
*Manu
Taketake
Te Makihere
Tamatahawai
Maru

Females.

*Wairipo
Takauere
*Hinepukopua
Mihitokorau
Makutu
Tapikauru
Terewa
Maruhingare
Waki
Tomina
Remukoho
Mourawea
Horomete
Tarauira
Waipu
Hitumata
Hinekukuwai
Ngahapi
Mariaro
Te Rikarawahine
Takarahui
Hinepata
Rongomaikehu
Hinemouta
Pauihi
Hituwahia
Horohoro
Huripapa
Hinepari
Takapori
Tanakarua
Hiwe
Tangorotehekina
Hikita
Wakauruhei
Hitahurangi
Purangai
Tarakawai
Pipikina
Hinekiato
Hinekopotanga
*Parau
Hinewaewae
Hiko
Tangohia
Tongarei
Rukoke
Wakawahine
*Hinemore
Tongawakua
Hinekarangapo
Maiterere
Tamamaira
Waiwangatupiupiu
Hinekoko
Tanahepua
Pukoko
Rengepe
Rongohere
Hinepangepange
Paitehapa
Makiri
*Maitaranga
Raukura
Tauhu
Totara
Kaaho
Hinekutu
Tahu
Te Kete
*Hiware
Rekanoi
Haruaki
Tanehape
Muruai
Te Itaka
Taurungatapo
Hitohunga
Tamakoenga
Huroro
Te Anawe
Takere
Hinekare
*Tarawanganga
Hineratapua
*Maroinui
Hinepatorangi
Te Karoa
Te Komore
Takitime
Te Rauataura
Wakahine
Hiore
Paturangi
Irikura
Turuwainui
Harongi
Hinekare
Poroa
Matenike
Hinemakua
Hinemakeri
Taumua
Maiteheri
Tarauatauru
Tangaropuna
Te Ratapu
Rato
Maihanuku
Te Akau
Hiwaki
Mangarangi
Porure
Hinepukiarenga
Hinerei
Woakahu
Hinekaehara
Maroro
Tahuru
Tiria
Hitarakaha
Terekereke
Muruoka
Kaniau
Poroporoaki
Kahutepuni
Tarakopeia
Te Harangamai
Kahutokorau
Koringamatau
Hikiri
*Tokuruhe
Kaorangi
Tuhoro
Tokamoro
Hinaua
Te Kore
Haruaki
Hinehope
Te Kiwai
Tauahorangi
Wati
*Tirikura
Mahianuku.

KAREWA AND WHANGAROA VILLAGES.

Males.

*Kaukuraweata
*Tamakapunga
*Tangarohaia
Hamita
Haurara
Matanga
*Tamatuhoto
*Tamoturangiauria
*Mairiki
Tamakapua
Tamakatoa
Tarakauna
Taupiki
Tokomae
Maikohiti
Waura
Papepe
Te Rangitapuariki
Tarakena
Tureka
Tungehu
Maituporo
Rokai
Mairikawa
Maitohokau
Tara
Rangomaihoroi
Rangitamounga
Poika
Kahukaka
Maitokoterangi
Taunawaho
Tao
Te Kotiongo
Tamakikiroa
Te Aha
Te Ingokore
Pahe
Tarerere
Tamakatau
Pakihau
Maniki
Tamatuawai
Hirapa
Te Angaangapohutu
Rangohiro
Te Rikitauru
Tamakotarawatu
Moremoreawa
Maitapatuataua
Kauru
Tamararare
Te Kumenga
Tamakokopu
Rangituranga

*Takorokoro
*Tamakouri
*Watukare
Tarapahinui
Tumukaretau
Te Wharepouri
*Te Homouri
*Rangimanomano
*Tamaturangi
Tamaaroaro
Tamahapi
Aharahame
Matua
Tangorokuma
Homeke
Ngotiwa
Tamakotuahe
Ngai
Tamakaroa
Te Ika
Mirikumu
Maitaitaka
Tamaniwa
Runanga
Te Pakuku
Ngunguparara
Tamakautu
Marakainga
Tamaroaroa
Tamarawara
Rongomaiiko
Kokana
Rakeiroa
Tamatahautu
Tiharuru
Tere
Te Rikihokeiri
Morehu
Te Pae
Tapurehu
Tangomaia
Karakaka
Ta Ata
Tapukokoe
Kaurumairi
Tamakuahi
Turangahau
Mahirea
Tahitarangi
Waitahuahi
Takinga
Taihango
Mawete
Te Waremate
Maitiaronga

*Tamanauwananga
*Tumatihiko
Wananganui
Hamori
Hawea
Waipaopao
*Te Rikipua
*Tamawanauturanga
Tinenga
*Rikengawai
Papauma
*Maitiangapoehu
Tupaka
Wakoko
Toropi
Rumaioe
Rakeihirikore
Tauata
Heri
*Tamokehanga
Kaumoeana
Tapata
*Maipari
Maiwere
Te Makana
Rangihamau
Tamairihi
Tapenga
Totomekere
Tutae
Kakura
Tamatohoro
Takume
Tamakeiate
Tamangoungou
Potiki
Maikopura
Tauwawataarangi
Maroroma
Tokomaru
Te Ingoru
Heiaa
Kamupero
Mawake
Puhakange
Tahakoi
Maitohokereroto
Koihau
Tamakerango
Tiniwetu
Mamaia
Karawanga
Te Kororangi
Te Rikipekepeke
Te Rikipapahura

Males—continued.

Muaru
Maitikitikitai
Maitoro
Rongomaiakura
Rongomaikaitoke
Wakarauika
Rangiwe
Tamaweke
Kakau
Rawiki
Tau
Te Rikiwawaura
Hori
Tiemi
Te Karaka
Te Rikipouri
Tamakonene
Ririma
Te Ureihora
Matawatu
Tapihirua
Te Rohe

Maungateke
Te Rohe
*Te Ika
Te Tatama
Te Amoko
Wetiwhi
Rangimariu
Meke
Tiori
Matahuna
*Tahei
Tamatiakiara
Horomahia
Wetinitara
Waiomawetini
Matai
Tauki
Tahipuku
Whata
Tapokoki
Maitorangi
Tamakoronu

Tamaherekapanga
Te Rikititaki
Rawairi
Wikaihia
Wetimore
Tihangaire
Ngamapeo
Tumingomingo
Kopa
Puawe
Kokana
Rangipawa
Pamipi
Tamatoke
Koromonakauri
Pahitoa
Tamamawaru
Rangipitoto
Tamatahiti
Te Kumu
Te Kare
Motukakana

Females.

*Hiturawahi
*Rakeiaoteika
*Tiria
Karapua
Moerangi
Kangarua
Tuhukura
Pinerei
Turangiauria
Wainohia
Pirikohurangi
Hinewairua
Rititia
Uwira
Tokarautahiri
Hiteorokura
Tongorewa
Waremoke
Hituroto
Moturua
Pouhiko
Makuku
Waipare
Hinekohiko
Hitohoropuwai
Hinemuka
Hinemuarau
Hapai
Putakina
Hinemokaipo
Hinemauri
Meranga

*Hirukaweka
*Mahuta
*Maritauru
Hitengaariki
Kuruwe
Hinepuharu
Kapiti
Tapeiri
Rerematongo
Moteata
Hinemarangai
Makutu
Hinepuwairua
Tiriake
Hinokerau
Tairei
Pakura
Waturato
Haumange
Tuake
Terekura
Te Rangipepe
Te Iki
Tiroa
Tumutauenga
Hitahuna
Rei
Karito
Tuauhanga
Tangoroheri
Te Hiore
Hauriki

*Koromatua
*Moeara
*Hitahunga
Hinematiwere
Mokoho
Mewa
Waitehei
Humatokarau
Maka
Tomekuparu
Moeara
Tapatu
Routu
Patakuwarere
Mohewao
Mihi
Marino
Kaipuke
Hukuwai
Puririri
Hinekarihi
Marino
Hinemaimao
Mahuta
Taiaroha
Pipitaua
Kura
Hinemitonga
Taumere
Nge
Tikitekara
Hinekopuatai

Females—continued.

Te Amai	Tururu	Ritatona
Tukato	Haumewa	Hitahunga
Rangihapahapainga	Kuraparangi	Muku
Mariunga	Tumai	Taikatu
Hitainga	Hituparu	Parawere
Tuahia	Tahurua	Te Ahunga
Te Amuruonuku	Hitaumu	Hautuarangi
Te Umukaroro	Numihara	Wairipo
Mahinateata	Hitaki	Mariri
Kuraupo	Rakura	Manurewa
Karapua	Te Pua	Tuarangamua
Ngarua	Ngarimu	Kinatona
Anawe	Omiria	Rohana
Haone	Hinepiripiri	Hine
Tuoterehu	Hitumaitai	Hautuarangi
Maritauru	Rititi	Hopae

OUENGA AND PATIKI VILLAGES.

Males.

Tutakumoana	Tamakakenga	Te Rikiwaiore
Miri	Maiturakina	Tamokoitiahe
Te Taura	Purehe	Tomotua
Peorohore	Te Rikitataha	Pehiroa
Taururu	Toi	Tokaroho
Ngarito	Towakia	Tuhainga
Rehua	Rangihemua	Rangituake
Tahuna	Te Rikihunga	*Matanga
Maungatea	Koti	Rongomaiterepu
Petaki	Ritini	Tume
Wakauranga	Waramange	Tamatuahu
Tamanauiriha	Tamangarua	Matukutuku
Takupuhanga	Putokotoko	Tuhatatao
Pitio	Tuhawiri	Tomatua
Tumutangi	Te Rikipakira	Matamakoko
Tangaroawatu	Rongowaiao	Tamehariro
Te Hawea	Tamurua	Rongotamaki
Tihaaokapua	Topango	Haihawahi
Putikimaro	Tawhiti	Tamatono
Tarauhutinga	Tapata	Maikona
Paia	Taputahi	Hirawaru
Rutapu	Tira	Kapaiariki
Ngai	Rangitokanga	Te Kumu
Maiteawaka	Rangiokehanga	Te Wakaarorua
Horanonopehe	Tamahokotiporo	Taenga
Tamihape	Tamunui	Watieriki
Tapiorokahu	Tainui	Taputehoro
Hurungana	Te Wakapuru	Hikihiku
Tanewiri	Torea	Titikipu
Uterepe	Rangitawawake	Potai
Rumatawewere	Tataitata	Tamanakare
Rangipewa	Tetereira	Maituhunuhunu
Makora	Tamakuneparea	Tahipa
Tuhapaiata	Ririmaunga	Hatunukuere
Puhakange	Hangore	Rutangoro

Females.

Hinewananga	Taranaki	Hinemutunga
Rauta	Hitatamaunga	Hinewaikono
Hinemotongo	Puanga	Hinepuariki
Te Kete	Hinepuku	Rautamui
Nukuwai	Hopuhopu	Hitapurukehu
Waimaunga	Maikara	Puangaiho
Turerekura	Te Matarae	Tongahepapa
Kahuta	Hihirawea	Rongomai
Hikoenga	Punanga	Tuawaimata
Hinemoia	Pingao	Hinekaputu
Hinepurongo	Hukuhuka	*Hinepukohua
Hinemarua	Poranihia	Tutemaungarewa
Kohutairi	Puroruanu	Rongotapakura
Poranihikikiwi	Hinekarohi	Hinekatipa
Rukutia	Motukaraka	Kurepae
Hinengawari	Puaho	Iriwaki
Haurumia	Wano	*Hinekurangi
Mukueke	Wakahu	Nuka
Uhana	Paraniho	Hitieki
Tumarae	Hiturakau	Hinepukera
Tirikoka	Te Maunga	Tongiatea
Tapuwakaiti	Harahiwarua	Pupurau
Rautipeke	Tanekopute	Taumukara
Hinehakana	Taumataarangi	Rekaweautururu
Rongorito	Homaitauku	Niwa
Tanehoe	Tanakanawea	Tutahiwere
Putonu	Pukaikana	Moanarua
*Monono	*Hineteakautahi	*Tauhiko
Papateanuku	Hine	Watiti
Te Watoi		

Otonga, Waiteki, and Rangiauria Villages.

Females.

Tanawaihoro	*Rapaki	*Hinui
*Maru	Tanahokanga	Titapu
*Tumai	Pipingore	Hikawaiiti
Pariri	Waneharuru	Huhuku
Awakino	Hutia	Rangitaumata
Tumuhawai	Kumete	Tuhanga
Hinengario	Panga	*Rakuru
Hinepata	Hiteteke	Rongonui
Hitorowaiariki	Tanamairewa	Karihia
Hiwareware	Hine	*Turikauna
Rakura	*Hinekoenga	Rahore
Hokopa	Purenga	Tikoko
*Terikauna	*Rongopapa	Kiware
Rakura	*Turikauna	Hinehora
Hinekowaowao	Tumukawanga	Karekare
Hitukaramea	Hoki	Hitowawa
Tuhara	Hinemaku	Putarakaha
Hineteohe	Te Atoro	Tanakerau
Puhao	*Hokopa	Heuwe
*Hetuke	Makohirangi	Hiteketeke
Hetu	Wananganui	Apia
Mokopo	Hinekaiahi	Pureti
Wakahotu	Pahau	*Teremoki
Tuwananganga	Hinepatitoka	Hitearoaro

Females—continued.

Purapura	*Niwa	Nganiko
Te Akau	*Naumapura	Nunanga
Ruhikari	Huwao	*Hinapoeho
Rumai	Kaikai	*Putongaariki
Hinepo	Hinarapau	*Hinetanakatoa
Tupapa	Manukau	Kahutopuni
Te Noi	Hitamataroa	Hopu
Waewae	Takahui	Apiaka
Himoru	Merepapa	Mairu
Himaere		

Males.

*Manu	*Tuweriki	*Tamatoenga
*Te Ro	Tamawake	*Tarangiwanangaiwa
*Tongatehau	*Rangitaketake	*Tahero
*Turangatari	Tamakauri	Te Rangiporure
Tahopuni	Tapurungehe	Tamahuro
Hingimanu	Te Koro	Rangimana
Te Ingoakore	Tapuwawahia	Mango
Tamaroro	Te Rikiwananga	Tamakohiti
Popoto	Tutorohiti	Tamakoti
Tamaporure	Pukurau	*Tapurangi
*Makawe	*Tapuhina	Hourangi
Tatahi	Pape	Mahama
Marukuru	Tawito	Parore
Te Wango	Mainui	Tamohokotau
Tamakopupu	Tamokotiahe	Piopio
Te Hiko		

Totals.

	Males.	Females.	Total.
Waikeri	240	119	359
Wharekauri and Tupuangi	122	70	192
Otonga and Waiteki	200	208	408
Karewa and Whangaroa	232	156	388
Ouenga and Patiki	116	101	217
Otonga, Waiteki, and Rangiauria	36	73	109
Total	946	727	1,673

Killed and eaten, 216.

Art. VI.—*The Site of Maupuia Pa, Miramar.*

By H. N. McLeod.

[*Read before the Wellington Philosophical Society, 2nd November*, 1904.]

In the "Transactions of the New Zealand Institute," vol. v., page 398, some particulars of historic *pas* of Miramar, known in native history as Hataitai, or Whataitai (murmur of the tide, salt air, or brackish) are given by the late Mr. J. C. Crawford. These are supplemented by a map indicating the places mentioned in his paper. Mr. Elsdon Best also mentions the *pa* which forms

the subject of this note in his paper in the " Polynesian Journal," vol. x., page 137, where he states that the posts were to be seen some forty years ago.

Among the various tribes that held Hataitai during its varied history were the Ngatikahungunu (*ungunu*, garment of the dwarf), whose descendants are to be found in the Wairarapa to-day. Of this tribe, the Hinepari (daughter of the cliff) were a sub-tribe. Under the chief Te Rahui (prohibited) this sub-tribe built Maupuia (hold to the scrub). There were several attacks made on the *pa*, but the besieged were able to beat their enemies off. The uncovering of human bones during the excavation of a site for Mr. Bell's house on the ridge, about 20 chains to the southwards, may be an evidence of one of these battles. Kokotahi (one tui) and Te Taniwha (goblin) were battles fought on the waters of Whanganui-a-Tara (Wellington Harbour), in which the Hinepari defeated their old enemies the Ngatiapa.

It was not the custom of the dwellers on the Miramar Peninsula to fortify their *pas* with earthworks, for the reason that rocky formation is met with under the subsoil. This makes it difficult to identify the site of *pas*. There are no indications of earthworks at Maupuia. Maupuia was situated on the narrowest part of the ridge overlooking Miramar Wharf, in Evans Bay. The spot is within three miles of the General Post Office, Wellington, as the crow flies, and the main road to Worser Bay runs below.

Upon searching for indications which would show exactly the site of Maupuia, the first evidence found was that of a large *umu*, or oven, which had been uncovered on the northern edge of the large cutting which gives access to the grassy flats formerly the bed of the Para Lagoon (named Burnham Water by Colonel Wakefield in 1840). It is upon the south side of the cutting, however, that the *pa* was built.

The recent subdivision (October, 1902) of Miramar enables me to give very exactly the spots where the posts and kumara-pits about to be described are situated. In the plan of the subdivision of Miramar and Evans Bay Estate, Queen's Terrace commences not far from Evans Bay wharf, at the southern boundary of Section 26, Block A. 6 ft. from the south-western corner peg of this section a totara post was found, the top of which was level with the ground. When unearthed it was found to be in an excellent state of preservation. There were no marks of tools upon it. At the bottom it was charred. From the fact of its being also charred on top it is inferred that the palisade of the *pa* was burned. The dimensions are: Length, 4 ft. 11 in.; girth, 4 ft. After a month's exposure its weight

is as much as an average man can lift with difficulty. A second post has been uncovered 15 ft. distant, between the survey peg mentioned and the peg at the angle of Queen's Terrace. This one is not well preserved. These posts must have been in the ground upward of a hundred years. 4 ft. from the first post is a kumara-pit, 7 ft. long, 5 ft. 3 in. wide, and 3 ft. 3 in. from the surface to the original bottom. Beneath 1 ft. of soil which has fallen in are charred pieces of totara, further evidence of the burning of the palisade. Side by side with this pit is one of smaller size. At various spots between where Queen's Terrace commences and Miramar cutting there are further depressions. There is a deposit of sand on the top of the ridge, now prevented from drifting by a growth of bent grass, and on its surface and in the soil are burnt *umu* stones and shells innumerable, as well as pieces of charred sticks, fish-bones, &c., and other evidences of the exercise of the culinary art. It is interesting to find that these indications occur where most shelter from the northerly winds is obtained.

It may here be mentioned that the sites of Tapu te Rangi, O-rua-iti, Kau-whakaara-waru, and Te Mahanga have been fixed more or less definitely. The sites of Kakariki and Te Matakikaipoinga still remain to be located, and to these may be added Paikakawa and Harukaikuru. I have recently been informed that earthworks of a *pa* exist on the summit of the range rising directly behind the churchroom at Worser Bay; also that totara posts were discovered in the ground during the construction of Fort Gordon.

ART. VII.—*The Balance of Trade.*

By H. W. SEGAR, Professor of Mathematics, University College, Auckland.

[*Read before the Auckland Institute, 20th June*, 1904.]

Plates III.–VI.

INTRODUCTION.

BY the "balance of trade" of a country is meant the difference between the imports and exports as ordinarily understood and recorded in its trade returns. In the usual and generally recognised method of calculating these returns the exports are calculated at their value at the port of shipment, and the imports represent the value of the goods at their place of origin plus the cost of freight and insurance. Transit trade is generally omitted, the imports then being goods for home consumption,

and the exports goods of home production. Such imports and exports are described as "special" when it is necessary to distinguish them from the total imports and exports, which include the re-exports, or goods of the transit trade, which are imported only to be exported again. Bullion and specie are usually excluded from the general returns, and separately accounted for.

Variations from this standard practice sometimes occur. For instance, the United States value their imports at the port of shipment, and do not add freight, insurance, and other charges. The imports of the United States thus appear considerably smaller than they would do if valued in the same manner as those of most other nations. Again, New Zealand and most gold- and silver-producing countries include these metals in the value of their exports. This, though varying from the recognised practice, is to some extent justifiable, as the production of gold in many of these countries forms quite a considerable proportion of the national industry, and the output of gold must be included in the exports if these are to give a fair representation of the commercial position. The United States, however, does not adopt this practice. These exceptions have to be carefully borne in mind in making comparisons. The question also as to whether re-exports are included or excluded should always be attended to before making application of any returns of imports or exports. In the case of the United Kingdom these re-exports reach now as much as seventy millions annually, and there are instances of places, as Malta, with small consuming and productive power whose trade consists mainly of this class of goods.

In what follows we shall generally speak of gold only, and deal only with the statistics of gold, and not of gold and silver. In the case of the nations from whose trade returns we shall take illustrations, the part played by silver in international transactions is secondary to that played by gold, and it is unnecessary to complicate the subject by taking both into account. It would, of course, be very different in the case of countries having silver standards; but even then the general argument would not be affected, though the statistics used would necessarily have to include silver.

The Graphical Illustrations.

Figs. 1–5 represent, by the usual graphical method, the balance of trade respectively for the United Kingdom, the United States, Germany, France, and New Zealand. An excess of imports is represented above the base line, and an excess of exports below it. Figs. 1–4 are drawn to the same scale, and so are suited for direct comparison; that for New Zealand is

on a scale which with respect to the vertical measurements is fifteen times as great. The graphs in figs. 1–4 are constructed from data deduced from those given in the volume of Memoranda and Statistical Tables (cd. 1761) issued by the Board of Trade. The statistics do not in any case go further back than the year 1854, because of the unsatisfactory nature of the returns before that date; while in the case of Germany, for a similar reason, they start from the year 1880.

The graph representing the balance of trade for New Zealand (fig. 5) is the only one representing statistics in which gold and silver are included; in the other figures the balance of import or export of gold is represented by a second graph. In fig. 1 the lower graph represents it for the years 1858–1902; in fig. 2 the dotted graph represents it for the years 1878–1902; and in figs. 3 and 4 the dotted graphs represent it for the period 1884–1902.

POSITIVE AND NEGATIVE BALANCE.

The balance of trade is commonly described as favourable when the exports are in excess, and as unfavourable or adverse when the imports are in excess. These words "favourable," "unfavourable," and "adverse," as thus used, are misleading, appearing to indicate as they do that an excess of imports is in some way disadvantageous to a nation, and an excess of exports an advantage. This use of the words originated in the old mercantile theory in which it was regarded as of essential importance to a country's prosperity to have, and to bring about by restraints on foreign trade if necessary, an excess of exports of merchandise and an inward flow of the precious metals. Very little consideration makes plain the unsoundness of such a notion; for an excess of exports, or the nominally favourable condition of trade, may be due to paying interest on loans, as in the case of New Zealand, and an excess of imports may be due wholly or in part to the receipt of interest, as in the case of the United Kingdom.

Adam Smith appealed to the experience of his time against the notions exemplified in the use of the word "favourable" as applied to the balance of trade. "There is no commercial country in Europe," he writes, "of which the approaching ruin has not frequently been foretold by the pretended doctors of this system, from an unfavourable balance of trade. After all the anxiety, however, which they have excited about this, after all the vain attempts of almost all trading nations to turn that balance in their own favour and against their neighbours, it does not appear that any one nation in Europe has been in any respect impoverished by this cause. Every town and country,

on the contrary, in proportion as they have opened their ports to all nations, instead of being ruined by this free trade . . . have been enriched by it." In other words, Adam Smith claimed that attempts to bring about by policy what was considered a favourable balance had been actually unfavourable to national prosperity.

It is not easy to avoid altogether the use of words which, in spite of their bearing on their surface the erratic ideas that were current during the infancy of the science of economics, have become part of the current phraseology of the mercantile world; but it is most necessary to dissociate them altogether in this connection from their ordinary connotation, and to regard them merely as indicating whether the exports or imports are in excess, without suggesting anything beyond. Indeed, it will be better for us to use the word "positive" as indicating an excess of imports, and "negative" as indicating an excess of exports. These words at least correspond to something tangible. Thus, when the balance of trade is positive, a country is obtaining for consumption an amount of products in excess of what she produces; and when it is negative the country has left to consume less than she actually produces. The words seem suitable; at all events they do not tend to convey entirely false notions to those who have not special knowledge or have not had special warning; and they will not have that fatal power which words sometimes have of cheating the mind, even occasionally of careful and well-instructed thinkers. In accordance with this terminology it will be convenient to speak sometimes of the balance of trade as rising when an excess of imports increases or an excess of exports diminishes, and as falling when the contrary movement takes place; and this will correspond exactly with the way in which we should speak in the ordinary course of the corresponding graphs in the accompanying figures.

We shall now proceed to consider the elements on which the balance of trade depends.

International Payments.

The transactions between nations are of much the same character as between individuals, and, except in the case of bankruptcy, the payments in goods and coin and services rendered on the one side must pay for those on the other, in a similar way. A nation may have to pay—

(1.) For goods received by it, including gold;
(2.) Interest on loans received by it;
(3.) The principal of loans advanced by it, or the return of the principal of loans borrowed by it;
(4.) Tributes or indemnities;

(5.) Profits of investments in its territory and owned by foreigners or others resident abroad;
(6.) Sums assigned privately by individuals — as by foreign residents assigning portions of their earnings to their families abroad, or by natives residing or travelling abroad drawing on their home resources, and so on;
(7.) For maintenance of its army, navy, and representatives abroad;
(8.) Charges and commissions for services rendered to it, as, *e.g.*, by the ships and traders, bankers, insurance offices, &c., of another nation.

And just as a nation may have to pay on any of these accounts, so she may have to receive on similar accounts. Thus a nation may have to be paid, just as an individual may, for services rendered, risk taken, capital lent, and so on—*i.e.*, for items other than the sale of goods. Thus, say, a million's worth of service rendered by a nation is essentially as truly an item of her exports as is so-much coal, iron, or cotton goods, and it is sold in the same way, just as the worker as truly sells the labour of his hands or brain as the tradesman sells his goods. The amount owing by other nations is determined by, and must include, these other items as well as the mere goods exported. Hence the term "invisible exports" was originally applied by Sir R. Giffen, and is now generally applied to these items of national earning-power other than the sale of visible material commodities.

We see, then, that a nation may be creditor or debtor to the rest of the world on many different accounts other than the sale or purchase of goods. In its foreign trade equal amounts of its imports and exports pay for one another, and the excess of merchandise and gold, either imported or exported as the case may be, settles an account in which is included capital borrowed, lent, or invested, interest and profits, and so on, as enumerated above. This account, and therefore the excess of merchandise and gold imported or exported, is independent of the buying and selling of commerce, and depends only on the relation between the country and the rest of the world in respect to these other matters.

Before pursuing this subject further, however, we shall consider the extent to which gold is used in international trade.

THE LIMITED USE OF GOLD IN INTERNATIONAL TRADE.

Erroneous notions on this subject are the cause of much of the false reasoning that is painfully common on matters of foreign trade. If we review the statistics which the illustrative figures exemplify we shall find that the use of gold in international trade is of a very limited nature. During the years 1858–1902 the

annual excess of imports of merchandise into the United Kingdom reached as high as £180,000,000, but the greatest excess of imports of gold did not reach £15,000,000, while the excess of export of gold reached only as much as £5,500,000. In the case of the United States the excess of exports of merchandise during the years 1878–1902 reached as much as £137,000,000, but the greatest excess of imports of gold was less than £21,000,000, and the greatest excess of exports was only £17,500,000. Germany's excess of imports was in 1898 over £66,000,000, but during the years 1884–1902 the greatest excess of imports of gold was less than £12,000,000, and gold was only exported in excess once, and that to the extent of less than £750,000. During the same years the excess of imports to France reached just on £48,000,000; the corresponding figure for gold is only slightly over £15,000,000, and the greatest excess of export of gold was only £6,500,000.

For the benefit of those who have any lingering suspicion that imports and exports, or the differences between them, are paid for in gold, we may repeat some of these facts. During the years considered for the several countries the annual excess of imports of merchandise into the United Kingdom reached £180,000,000, but her excess of export of gold was never as much as £5,500,000; the excess of exports of merchandise from the United States reached £137,000,000, but she never imported in one year an excess of gold as much as £21,000,000; Germany imported an excess of merchandise of over £66,000,000 in one year, and in only one year of the nineteen did she export any excess of gold at all, and that only to the extent of a fraction of a million; lastly, France, with an excess of imports reaching nearly £48,000,000 in 1891, sent out an excess of gold only reaching at most in one year £6,500,000.

But not only does the excess of import or export of gold in any year not bear comparison with the excesses that we generally have of merchandise, but it is to be further noted that the graphs representing the gold balances, unlike those representing the balances of merchandise, fluctuate generally about the base line: one time there is an excess of imports, at another an excess of exports, according to the fluctuations of trade. If, then, we take the totals for a number of years back, instead of the separate annual returns, we shall find the excess of imports or exports of gold bearing a much more insignificant proportion to the corresponding figures for merchandise, the excesses of imports and exports of gold in different years to a certain extent balancing one another. The excess of imports of merchandise, for instance, to the United Kingdom, during the period 1858–1902, was £3,984,000,000, and, instead of there being an excess of export

of gold, there was an excess of import of gold also to the extent of £170,600,000. But in order to have a period for which we can compare the similar statistics for the other countries we shall take the years 1884–1902, the first of these years being the earliest for which I have the returns of the gold imports and exports for all four countries by me. During this period the United Kingdom had a total excess of imports amounting to £2,456,600,000, and there was also an excess of imports of gold amounting to £91,700,000; the United States had a total excess of exports of merchandise amounting to £866,000,000, and likewise an excess of exports of gold amounting to £14,900,000; Germany had a total excess of imports of merchandise amounting to £700,700,000, and likewise an excess of imports of gold amounting to £60,700,000; and lastly, France had an excess of imports of merchandise amounting to £513,500,000, and likewise an excess of imports of gold amounting to £83,500,000.

So far, then, are the actual circumstances from justifying the idea that a country is paid for its excess of exports or pays for its excess of imports in gold, that we have found, in the case of the four leading commercial nations, during the recent period of nineteen years, that in the countries where merchandise is imported in excess gold also has been imported in excess, and that the one country which has had an excess of exports of merchandise has also had, on the whole, an excess of export of gold.

In the case of England, Germany, and France there must of necessity be on the average a predominant import of gold, as these countries produce none themselves, and yet require a certain amount for the expansion and renewal of the coinage, the manufacture of jewellery—a considerable value of which is exported—and for general application in manufactures and the arts. Such an amount of gold as is required for these purposes has to be imported like any other necessary material not produced at home. That the amounts imported by these countries should be so nearly comparable as are the values of the total excesses of imports of gold—namely, £91,000,000, £60,000,000, and £83,000,000—is not then a mere coincidence. The differences between these values and those actually required for the purposes referred to are only small amounts, comparable with those that are imported and exported in periods of two or three years through the ordinary fluctuations of commerce. This constitutes an absolute demonstration from the statistical side alone that these effects are not cumulative—that is, that a nation cannot continue for any but a comparatively short period to have an inflow of gold over and above what is required for use and consumption.

The case of the United States is not an exception, for, although we have found that during the period considered she exported in the total an excess of nearly £15,000,000 of gold, yet when we allow for the production of gold in that country, which amounted to £188,000,000 in the same period, we find she had £173,000,000 for home use. This amount is considerably larger than for any one of the other three countries, but no more perhaps than might be relatively expected from the rapid increase in the numbers and wealth of the population.

It will be noticed that the import of gold by the non-gold-producing nations has been greatly stimulated of recent years. This is a consequence of the greatly increased production of gold. The large amounts of gold produced can only find an outlet by finding their way into the various countries, and to a large extent into the several currencies, enlarging the same and producing higher prices. The amounts of the excesses of imports of gold we have considered above would have been much less again but for this cause.

It is not difficult to see that the use of gold in commerce is thus limited, because it could not well be otherwise. Even if a nation were minded to pay for her imports with gold, she would find it impossible to achieve her object. If it were possible to export every coin in the country, any one of the great countries we have been considering would, in attempting the feat, be left without coinage in a few months.* The United Kingdom, if she paid in gold even only for the *excess* of her imports over her exports, would be without gold in about six months only.

But, as commerce is actually carried out, the importer does not send a box of gold in payment for his goods, nor does the exporter receive any such, but gold or credit, and generally credit, is passed on to a fellow-townsman or fellow-countryman. What passes between nation and nation consists mainly of drafts and bills of exchange. The rates of exchange tend to resist even the passage of the smallest amount of gold, and, by discouraging imports if they tend to come in in excess and encouraging exports, or *vice versa*, tend to make the imports and exports keep their proper balance as determined by the several factors of international indebtedness, without the passage of gold.

To quote the words of Professor Nicholson: "If there is at any time an excess of imports into a country, the importers (through their brokers or agents or correspondents) will find that they must pay more for foreign bills. This increase of cost will no doubt affect all, but not to the same extent. Some of the

* The Director of the United States Mint estimated the stocks of gold in these countries to be: United Kingdom, £91,000,000; United States, £192,000,000; Germany, £138,000,000; France, £167,000 000.

imports will (compared with the great bulk) have yielded little or no profit, and some of the importers will have little or no credit. The fall in the exchange will tend to check these scarcely profitable or marginal imports, and also to stimulate the exports of a similar character. Some of the importers may be unable to meet their engagements, others may be obliged to accept onerous terms for postponement, and others will purchase the bills drawn against the additional exports. In this way it is seen that the balance of imports and exports will, in ordinary cases of inequality, be restored by operating directly upon the doubtful margins, and not by general operations on prices."

If gold, though, has eventually to pass to settle international transactions, a portion of it, of course, may be what is required on account of the general requirements we before considered. Gold must, apart from temporary fluctuations, be distributed amongst the nations so as to be accommodated, in the words of Ricardo, " to the natural traffic which would take place if no such metals existed, and the trade between countries were purely a trade of barter." New Zealand, for instance, must export the main bulk of the gold she produces, and, this being a comparatively steady quantity, there is a relation between her average prices and those of the rest of the world which brings this about. Similarly, countries which do not produce gold must import a certain average amount depending on their needs. But any gold which passes in excess or defect of this amount, though it may do so temporarily without affecting prices or credit, merely diminishing in the one country and increasing in the other the bankers' reserves, must, if it remains, increase credit and prices in the receiving country and lower them in that which has lost the gold. An addition of, say, £10,000,000 represents a considerable proportionate increase in England's stock of gold. Were such a sum to get into circulation it would be sufficient to raise her average prices substantially, and so check her exports, while the prices of foreign goods would be relatively low, and this would give imports an impetus which, aided by the diminished exports, would tend to again withdraw the gold. Thus prices change in a way which ultimately offers a decisive resistance to the former tendency, and may promote a reaction.

And so this abnormal stream of gold ebbs and flows, always in relatively small quantities, according to fluctuations in business. The direction of the flow at any moment does not depend on relations of permanent indebtedness, but on the accounts that are due at the time. Gold may flow into a country that is on the point of becoming hopelessly insolvent; it may be an outward and visible sign of the payment of her last loan, which, however, would mainly be received in the form of goods.

A change in fiscal policy may cause a limited flow of gold for a time which has no tendency to return, with the result that the country permanently retains a greater or less amount of gold than would otherwise have been retained. Suppose, for instance, that the duties on imports were raised. If the change were sufficiently considerable and extensive to diminish the volume of imports, exports would be discouraged as a consequence in the manner described above. If the effect on the exchanges were not sufficient to reduce the exports from what they would have been in the absence of the increases of duties by the same amount as the duties diminished the imports, gold would have to pass, but only to the extent necessary to raise prices to the level necessary to diminish the exports by the necessary amount. The country would then use more coins in carrying on her internal trade at higher prices, and other nations would have the privilege of consuming the goods she produced in exchange for them. These effects are, of course, those which would ensue other things being the same, but in actual cases they are generally effective merely in modifying those fluctuations, due to other causes, which are always taking place in commerce, and the extent of which is obvious from the changes taking place from year to year in the balance of trade, as clearly indicated in figs. 1–5. Consequently it is generally difficult to trace these effects of a change in tariff, especially as such changes are generally more or less gradual, and when severe are so only on a very limited number of articles and not on the whole mass of imports. Increases in duties may, for example, be made just about the time when a period of extensive foreign investment is setting in, with the result that gold may be exported instead of imported, though the latter is the effect which the increase in duties would tend to bring about if operating alone.

Exports paying for Imports.

We can now understand clearly what is meant by what we often hear—that imports are paid for by exports. This would obviously be untrue if by it were meant that imports and exports are of equal value. But this is not in the least intended by this statement. It is, I imagine, by this time hardly necessary to say that it is used by way of brevity for a principle which cannot be accurately stated in a few words. And this principle is substantially this—that, other things remaining the same, an *increase* in imports, that has to be paid for, is paid for in the end by an increase in exported goods; or, if foreign products are consumed, the total home production is not ultimately lessened in value thereby, though of course it will be changed in character. Gold may pass to a certain extent, which, however, is only trivial compared with the total volume of trade; but any such passage

cannot continue beyond what is required by and determined by the necessities of the country. A demand for foreign products, then, is ultimately a demand for an equal value of home products, and this is what is chiefly in view, as a rule, when it is said that exports have to pay for imports.

It is often lamented that we in New Zealand import this from America, that from Germany, and something else from England. But it should be understood that if we imported nothing we should export only about as much as would be needed to pay interest on our debt; and if we took no canned fruit, no soap, no leather, and so on, we should export less mutton, less wool, and less butter. The fact that our people prefer to produce butter and mutton shows that we could only exchange to our own disadvantage a portion of those industries for the others we pine after. By protection we can undoubtedly foster the smaller industries which do not already completely supply our wants, but it is at a greater loss to the great staple exporting industries and to the nation at large.

There is not, of course, intended any suggestion in what we have said that the balance of trade must remain constant; in fact, we have seen that it fluctuates rapidly within short periods. But these changes have now been proved, both statistically and theoretically, to be due in only a very minor degree and only temporarily to foreign goods displacing home-made goods, or the reverse. The balance of trade depends on the many elements we enumerated in the early part of this paper, and any but the more temporary fluctuations are mainly due to operations in the loan market and great movements of capital. When a nation borrows or lends abroad, a change in the balance of trade represents the transaction, and so also when any of the factors of international indebtedness are changed. But the ordinary transactions of trade do not affect these. If a merchant in Auckland orders a large supply of cotton goods or hardware, the Government does not as a consequence issue a new loan. And so an increase in importations brought about and to be paid for in the ordinary way of business must call forth an equal increase in the exports of goods. The effect of a single transaction may not be very visible, as a single drop of rain may not appear to raise the level of a large lake, but nevertheless the level is raised always to an extent proportional to the amount of rain that falls. The effect of the single transaction is there: it only wants the assistance of some others to be patent to all.

IMPORT DUTIES.

We have seen that a restriction, in the form of duties, on imports must, after a time, equally restrict exports. Similarly,

duties levied on exports, either by the exporting nation or that receiving the goods, must in the end restrict the imports as much as the exports. In either case the injury done to the total trade is double of that done to either part of it. If, then, a nation, through discontent at restrictions inflicted by foreigners on her trade, herself decide to tax her imports, she merely duplicates the injury. Foreigners having reduced the volume of her trade by the levying of duties, she practically decides to reduce it still further. The foreigners have reduced their own trade by their duties, but are unconscious as a people, no doubt, of their self-inflicted injury. They may be very sensitive to the injury done to their exports by the duties of others—this injury is direct and patent, and their attention is riveted on their exports; but the injury done to their exports by their own duties on their imports is indirect and therefore unknown to the great mass of the people and, unfortunately, of statesmen. Yet the injury which is self-inflicted is greater than the other, for if a nation restricts her trade by import duties she experiences the full effect on her exports, but each of her rivals only bears a share on theirs.

It is worthy of notice that in the case of England any damage to the import trade brought about by the levying of duties would produce a much greater proportionate effect on the export trade. Of late years the import trade has been almost exactly half as much again as the export trade. Consequently, *e.g.*, the reduction of the import trade by one-third would involve the reduction of the export trade by one-half, and the reduction of the import trade by two-thirds would practically obliterate the export trade altogether. In addition to the direct loss involved in the diminution of export trade, we have further to consider that, England being the great carrier of the world, and carrying much the greater portion of her own trade, the loss to shipping has to be added to that of exports, a feature that is of smaller importance and generally insignificant in the case of other nations.

Such are the plain *direct* effects of import duties on foreign trade. They do not affect greatly or permanently the balance of trade, and they do not therefore increase employment, but they diminish foreign trade and the advantages that accrue from it, and in the case of England they would diminish the amount of employment for her shipping. There are many refinements and secondary effects that one might discuss and ought to discuss in any attempt at completely describing the effect of import duties, but the only object here is to explain briefly and to emphasize these simple considerations, which are fundamental, but which are commonly misunderstood, and even when understood are too frequently lost sight of. Without frequent references

to them reasoning on matters connected with foreign trade is only too certain to err, and it is impossible without having regard to them to give their proper weight to many other considerations that are in their nature valid.

STATISTICS OF THE BALANCE OF TRADE.

Coming to the actual study of the statistics of the balance of trade, we may note that the chief of the items already enumerated as represented by the balance of trade are generally (1) interest on loans and profits on investments; (2) capital; (3) sums transmitted on account of individuals; (4) payment for services rendered.

That interest on loans and profits on investments may be a large item in a nation's account will be generally understood, and we all know that some nations are always borrowing and others lending. It may not at first, however, be realised how important the third item may be. In the report for the year 1891 on the foreign trade of Italy it was estimated that foreign travellers brought at least £21,000,000 into the country, £7,000,000 of this being due to American citizens alone; while Mr. C. P. Austin, Chief of the Bureau of Statistics, United States, estimates the expenses of American tourists abroad at from £15,000,000 to £20,000,000 over the expenses in America of foreign tourists. Again, it is estimated that in France the general travelling public, and the winter residents in the south, spend annually about £15,000,000. The fourth item, that of payment for services rendered, is particularly large, as we shall see presently, in the case of the United Kingdom on account of the services rendered by British shipping.

In considering the balance of trade it is well to remember that unless a nation is making payments abroad it is the normal state of things for the imports to be larger than the exports. If goods are exported they sell for a price greater than their price in the exporting country by the expenses of shipment, including insurance and other charges. The goods bought abroad are generally entered in the imports at a value including their cost, insurance, freight, &c. The increased value is due mainly to the services of shipping, and if foreign shipping be employed the increase in value for the most part goes to the carrying nation. But most nations employ, more or less, their own shipping, and so appropriate to themselves some of their extra value. In some cases, as in that of the United States, the statistics of imports, instead of giving their values as landed, give the values of the goods when shipped abroad, and so do not exhibit the increase in value. But even with a number of such exceptions it is found that when the total imports of all the chief

countries of the world are added together they exceed the total exports by a sum in the neighbourhood of £250,000,000. This, apart from inaccuracies in the statistics, represents the value added by shipping and allied services, and the United Kingdom, by her great mercantile fleet and commercial services, must secure nearly one-half of this added value.

Again, it should be carefully borne in mind that it does not in the least follow that a country is prosperous because it has an excess of exports, or the reverse of prosperous because it has an excess of imports. An excess of exports may, it is true, be due to great wealth and an increase in the foreign investments of its citizens, but it may be due to the country having to pay interest on loans contracted in the past, or to the fact that much of its industry is exploited with foreign capital and its profits have to be sent abroad. An excess of imports, again, may be due to poverty of native capital, to borrowing, or to the withdrawing of foreign investments, and the living of the nation on its capital, but it may also be due, in whole or in part, to the receipt of interest on loans and profit on capital it has advanced, or it may be due to payment for services rendered. Thus neither an excess of imports nor an excess of exports can be considered in itself as being favourable or unfavourable.

Also observe there is no necessary relation between the magnitude of the balance of trade and the volume of trade. The balance of trade may be depressed (*i.e.*, smaller than at some time previous and some time afterwards) at a time when trade is exceptionally brisk, and the balance of trade may be inflated when trade is exceptionally slack.

Once more I may point out that there is no necessity for gold to flow out of a country when the balance of trade is exceptionally high, or to flow in when the balance is exceptionally low. In fact, gold may flow in with other goods, and out with other goods, in discharging for the nation the obligations of the moment. A very cursory glance at figs. 1–4 will show that the balance of imports and exports of gold bears no correspondence to that of general merchandise.

One other feature strikes us at once on contemplating these figures, and that is the great fluctuations. The line as a whole rises, for instance, in the case of the United Kingdom, and falls in the cases of the United States and New Zealand. The rise or fall, however, is on the average wave-like. There are a few years for which the line is higher than for neighbouring years; then after a depression for a number of years the same thing happens again. But this, again, does not come about uniformly: there are irregular changes from year to year, though these changes are generally not comparable with the difference between the

highest of a maximum period and the lowest of either of the adjoining minimum periods. These maximum and minimum periods are due to the movements of capital, but we should be careful not to exaggerate their importance. Investments may often be diverted either from foreign trade to home trade, or *vice versâ*, with advantage, and any such considerable movement makes a great change in the balance of trade in one direction or the other. Although such great importance is usually attached to the value of the exports, it is true that the very prosperity of a nation, giving full employment to its capital, may be such as to diminish for a period its exports, either absolutely or relatively to the imports, by leaving it little or no surplus capital to be invested abroad; and a flight of capital abroad, increasing the exports, may be due to want of opportunity at home. The former seems recently to have been the condition of both England and Germany, which, during a period of almost unprecedented prosperity, increased their imports far more rapidly than their exports. That a great growth of the imports is consistent with great national prosperity is well illustrated by a table issued by the Board of Trade, showing that whereas during the years 1893–99 the value of manufactured and partly manufactured goods imported into the United Kingdom increased from £98,000,000 to £140,000,000, the percentage of members of trade-unions unemployed diminished steadily from 7·5 to 2·4 —*i.e.*, to less than one-third of the former proportion. On the other hand, it was in 1886, when the exports came nearer in value to the imports than they had done for twelve years, that the acute commercial depression set in.

BALANCE OF TRADE OF THE UNITED KINGDOM.

Fig. 1 illustrates the balance of trade of the United Kingdom from 1854 to 1902. From 1899 onwards the graph is double: the lower line gives the balance of trade when the exports of ships and their machinery are taken into account, and the upper line when they are not. The values of these exports were first given in 1899, though the tonnage, from which a rough estimate of the values can be found, is given for a much longer period. The item has in recent years been a much more valuable one than ever before, and has in some years exceeded £9,000,000 in value —too big an item altogether to be left out of account in the total of the exports, though its inclusion now and its omission formerly vitiates to some extent comparisons between different periods. For this reason it is as well perhaps to exclude it from actual values compared, though allowance should always be made mentally for its great increase in value.

We have previously described the general character of the

changes in the balance of trade for the United Kingdom. We see quoted sometimes with alarm the great rise from £81,000,000 in 1887 to £183,000,000 in 1903, a change averaging nearly £6,500,000 a year over a period of sixteen years. But this change is in character and magnitude by no means unique. In the five years from 1872 to 1877 the balance of trade rose from £40,000,000 to £142,000,000, an average of £20,000,000 a year. That such changes need not be due to freedom of trade is clear when we compare with them corresponding changes that have taken place in the commerce of other nations that have had in operation considerable protective duties. The balance of trade of Germany increased from a negative balance of £5,000,000 in 1886 to a positive balance of £53,000,000 in 1892, and further to £66,000,000 in 1898, being an average of £10,000,000 a year in the earlier period, and of £6,000,000 a year during the whole period of twelve years. The balance of trade of France increased from a negative balance of £13,500,000 in 1875 to a positive balance of £62,500,000 in 1880, an average annual increase of £15,000,000. These changes during comparatively small periods in the balance of trade in Germany and France are quite as considerable, or, relatively to the total foreign trades of the respective countries, more considerable, than those for the United Kingdom.

If there are any peculiar features in the balance of trade for the United Kingdom, they do not consist, then, in the fluctuations that take place during five, ten, or fifteen years, but in the great magnitude of the balance of trade as it stands at present, and in the way it has increased, not merely during the last few years—which increase may be considerably affected by one of those temporary fluctuations which the trade of no nation can be freed from—but, apart from such fluctuations, for the whole of the period which fig. 1 illustrates.

The dotted line serves to show roughly the general trend of the balance of trade. It will be noticed that the fluctuations in the graph of the balance of trade relatively to this line represent changes not at all considerable compared with the total volume of trade. The average rise during the whole period is less than that during the years 1872–77, or during 1887–1902: during each of these latter periods we have a temporary fluctuation combining with the rise due to the more permanent causes in operation, producing a very rapid rise, but even then such only as can be paralleled, as we have seen, from the balances of trade of other countries. It is grossly unfair to compare the balance of trade for a minimum year with that for a maximum year without distinguishing these two elements.

Of late much has been made of this rise in the balance of British trade. But before we can infer anything as to the sound-

ness of British trade and prosperity from this rapid growth it is necessary to analyse its contributing causes.

Now, to begin with, England, as a great capitalist nation, possesses capital all over the world advanced as loans and invested in industries and commercial undertakings. From this she has to receive interest and profits. Now, in 1901–2 the profits that could be identified as foreign for income-tax purposes was £62,500,000. But the Board of Trade report on British and foreign trade and industry points out "that this total only includes foreign and colonial securities, coupons, and railways, and hence is exclusive of the return on British capital invested in a large number of miscellaneous industrial enterprises abroad. It is, moreover, certain that the profits assessed to income-tax form only part of the whole, and that some of these profits escape assessment, while others are not identified as foreign. . . . We are justified in concluding that £62,500,000 is a *minimum figure, which is probably largely exceeded*, though we are unable to say by how much." Sir Robert Giffen in 1898 estimated the total at £90,000,000. There is no one in a better position to judge, and his authority is admitted and his estimates accepted by many who would be glad to be able to reject them if they reasonably could.

Another item for which England has to receive payment is the services of her shipping. It is impossible here to go into the detail by which this matter has been investigated. It is sufficient to notice that, making every allowance for expenses incurred abroad in connection with the carrying trade, the Board of Trade report regards £90,000,000 again as a minimum estimate of the amount of imports earned by British shipping.

These two items are the greatest, but there are many other which, though of smaller amount, are yet each substantial, and probably in the total very considerable. But these are even more difficult to investigate than the others. All we can say is that the best statistical talent that England can supply is agreed in assigning £180,000,000 as the smallest possible income derived from abroad at the present time in respect to the two main items alone.

When any comparison is made between any such estimate as to what the United Kingdom earns abroad and the balance of trade, it is to be remembered that the degree of accuracy with which the values of imports and exports are returned is of great importance. Such errors as exist are probably comparatively unimportant in comparisons of like returns for different periods, for they no doubt tend in the same direction at different times, and are roughly proportional to the totals. But in comparing an estimate deduced from them with one derived from altogether

different sources, and therefore not affected by these same errors, it would be wrong to ignore them. As we are dealing too with the estimated *difference* of the imports and exports, the error in this difference may bear a much bigger ratio to it than the errors in the estimated imports and exports do to these respective returns, especially as the errors in these may take different directions, either the imports or the exports being undervalued and the other overvalued. Indeed, the exports are undoubtedly undervalued in many instances in the effort to escape a portion of foreign Customs duties. There is no such tendency in respect to undervaluing the imports, as these are mostly free from duty, and those that are subject to duty are mainly of a character which do not lend themselves easily to this manner of deception. In some cases, many think, imports are overvalued for trade purposes in the United Kingdom, as, when it costs nothing, the tendency is to exaggerate the business done. Both these tendencies act in the way of increasing the apparent balance of trade.

It is thus difficult by making the comparison we have criticized to deduce anything precise as to the rate at which England is annually investing abroad, or as to how much, if any, she is withdrawing. Some have proved in this way to their own satisfaction that England has recently been living on her capital, that English investments abroad are diminishing in value, or that the volume of American investments in England is becoming phenomenal; but the data will not support such conclusions. For one thing, the margin of error is altogether too large. Moreover, the income-tax returns yearly indicate a continued increase in the total value of British incomes derived from foreign sources. This is sufficient in itself to settle the point.

But, looking backward and comparing the present with the past, it appears to me plain that, if England is in a critical position now, she was at least about equally so in and about the year 1877, for in that year (no less than twenty-seven years ago) her excess of imports as recorded reached £141,000,000. The excess of recent years does not appear relatively as great as this when we consider the advance in earning-power of English investments and shipping. From 1882–83, five years after the year considered, to 1901–2 the annual profits from abroad assessed for income-tax increased from under £32,000,000 to £62,500,000, or by nearly 100 per cent.; and although part of this increase may be due to greater stringency on the part of the inland revenue, it must represent for the most part a real increase. The other sources not revealed by the income-tax returns no doubt increased in a somewhat equal ratio. Again, from 1880, three years after the period considered, to 1902 the tonnage of British shipping increased from a little over 6,500,000 tons to over 10,000,000 tons,

or, roughly, about 50 per cent. But it has to be further remembered that in 1877 more than half the tonnage consisted of sailing-vessels, whereas now the tonnage is about 80 per cent. steam, and steamers, by reason of their greater speed, have an annual carrying-capacity of about three or four times that of the same tonnage of sailing-vessels. To put it moderately, then, compared with 1877 the British excess of imports at the present time is not relatively greater, and if it is to be reasoned that Britain is now in a bad way because of it, it must also be concluded that she was then also in a very parlous state. We do not now hear that she was then living on her capital, although the alarmists of the time loudly proclaimed their conviction of the fact. Indeed, according to the estimate of Mulhall, the amount of British capital invested abroad increased during the decennial period 1872–82, in which the year 1877 is centrally situated, by £275,000,000, and interest on this and other more recent investments are now being received. Indeed, the total estimate of British capital invested abroad was £600,000,000 in 1872, and £875,000,000 in 1882, whereas now it is estimated at not less than £2,000,000,000. If, then, in the years about 1877, when the excess of imports reached £142,000,000, England was still investing abroad at such a great rate, surely now, with so much more valuable shipping, and so much more capital invested abroad, she is able to import an excess of £180,000,000 without living on her capital.

And what happened after 1877? There was a great drop in the excess of imports, and ten years after the excess was less than £81,000,000, as five years before it was only £40,000,000. There is every reason to anticipate that we have now similarly reached a maximum in the balance of trade, and that, as before, the further trend of the graph in Fig. 1 will be for a time downwards.* Then a rise again in the balance of trade to £200,000,000 or more in some future year will convince the alarmists of the future that England is living on her capital, though they will be willing to admit that she was not doing so in the year A.D. 1904.

BALANCE OF TRADE OF THE UNITED STATES.

Owing to the imports of the United States being valued according to the value at the port of shipment instead of that of importation, the graph representing the balance of trade in Fig. 2 would have to be altered somewhat in form, and raised as a whole relatively to the base line, to make it strictly comparable with those for the other nations. But taking the returns as they are they show that whereas the United States had at one time an excess of imports, she has had annually since 1876, with three exceptions, an excess of exports. Allowance must, however, be

always made mentally for the peculiarity of American returns of imports, which causes an excess of imports to be underrated and sometimes converted into an apparent excess of exports, and an excess of exports to be overrated.

In past time vast amounts of foreign capital, chiefly English, found their way to the United States, until the interest and profits on these amounted to a greater sum than that finding its way into the United States. We have now reached the time when the amount of foreign capital annually invested in the United States may relatively be ignored, and when the United States, with her great wealth and vast developed resources, will, especially during or after exceptionally prosperous periods, send out capital to pay off loans, buy American investments held by foreigners, and even to make investments abroad. The great drop in the line of the figure occurring from 1897 onwards undoubtedly represents a period when this feature was exceptionally prominent. It will no doubt be the general tendency for the excess of exports to increase, but unevenly, and the present great excess will probably be succeeded by a period in which the excess will be very much less before the present record is again exceeded, just as the great corresponding change from an excess of imports of £38,000,000 in 1872 to an excess of exports of £55,000,000 in 1879 was succeeded by a change to an excess of imports again of £6,000,000 in 1888.

It is interesting to consider how, in the opinion of Mr. C. P. Austin, chief of the Bureau of Statistics, the excess of exports is explained. He went into the matter in May, 1901. He reckons that the United States, unlike the United Kingdom, has to export £10,000,000 in payment for the service of foreign shipping (although estimates differ greatly, and some put it as high as £30,000,000), from £15,000,000 to £20,000,000 in payment of dividends and interest on foreign capital, and from £15,000,000 to £20,000,000 as the expenses of American tourists abroad over and above the expenses in America of European tourists. The balance for the most part would go abroad in the form of capital in any of the ways specified above.

The inference would appear to be, if these estimates are reasonably close, that from 1898 to 1901, when the United States exports reached the maximum, the annual flow of capital abroad together with the withdrawal of foreign capital from the States varied something like from £70,000,000 to £100,000,000. This appears at first vast, but when we compare her great area, population, and resources with those of England, and remember that the corresponding average sum for the eleven years 1882–93 in the case of the United Kingdom was no less than £75,000,000, we need not be surprised at something even greater in the future.

If we are to be able to judge changes in commerce impartially and without panic we must view things as they are, and get rid of the notion that it is possible by any means whatsoever to reserve for all time pre-eminence in the wealth and commerce of the world for one small island. There must be indisputable merit in a system that has kept it there so long.

BALANCE OF TRADE OF GERMANY.

The line in fig. 3 representing the balance of trade for Germany is only given as starting from the year 1880, as no comparable statistics can be given for previous years owing to the great changes in the methods of compiling the German import and export statistics which took effect in that year. But the fragment that is given is of great interest. It shows a great rise beginning from the year 1886. In 1886 there was an excess of *exports* of £5,000,000, and this changed by 1898—*i.e.*, in twelve years—to an excess of *imports* of over £66,000,000. The total change in the balance of trade was thus £71,000,000, in the direction which is commonly regarded as unfavourable.

It is worthy of particular notice, too, that this change succeeded the adoption of rather high protection by Germany—which must be of particular interest to such as may still entertain any belief that protection favours exports at the expense of imports.

The far more rapid growth of German imports than of exports in this period tells us that if Germany has been sending her goods abroad to a greater extent than before, she has increased her purchases from the rest of the world to a far greater extent. It will be noticed that the import and export of gold is steadier in the case of Germany than in that of the other countries, and that in no year since 1884 has there been any balance of export of gold. The import of gold necessary on the whole has been sufficiently regular to effect a balance of imports in each of these years. This feature is undoubtedly the result of the policy of the State bank of Germany. This is well described by Mr. George Clare as follows: "As to imports, the Reichsbank accelerates them by the simple and legitimate expedient of paying a better rate for foreign gold coin than the tariff price of other State banks, and, in addition, by sometimes bearing the few days' loss of interest incurred in bringing the gold over. To circumvent exporters is doubtless a task of somewhat greater difficulty, but apparently not beyond accomplishment. In the first place the bank immediately parries the demand by putting up its rate, and secondly, in order to gain delay until the increased rate has had time to act, gives the big banking-houses to understand, so it is said, that there are sometimes higher issues to be

considered than mere profit, even in business matters, and that to weaken the national reserve for the sake of gaining a paltry half per mille or so will be regarded by it as an unfriendly and unpatriotic action. As the State bank is powerful for good or evil, there are few bankers in Germany who would care to run the risk of offending it, and hence its wishes are usually respected." ("The A B C of the Foreign Exchanges," pp. 131–2.) In this description the words "import" and "export" refer to gold.

Balance of Trade of France.

In the graph in fig. 4, representing the balance of trade for France, the great rise taking place between the years 1875 and 1880 is conspicuous. During that short period an excess of exports of about £13,500,000 changed into an excess of imports of nearly £63,000,000, the total change in the balance of trade being over £76,000,000 in five years. It corresponds very closely in point of time with the rise in the balance for the United Kingdom which took place during the years 1872–77, and with the considerable fall in the balance for the United States which took place in the years 1872–79. Before this rise in the latter years of the seventies the French balance had been hovering about zero, the imports just about balancing the exports except for fluctuations of usual amount from year to year. Since the rise the balance has been falling pretty steadily on the whole, until it has now almost reached its former condition. This probably indicates that when we allow for the earnings of her shipping, which has about one-tenth of the tonnage of that of the United Kingdom, the investment of French capital abroad is about equal to or rather greater than her income from former investments. It is well known that France is now a large investor abroad.

Balance of Trade of New Zealand.

In the case of the balance of trade of New Zealand, illustrated in fig. 3, gold is included amongst the exports. The same general feature strikes us as in that of the United States —namely, the change from an excess of imports to an excess of exports; and although when the change from the one to the other took place the circumstances were much the same in both countries, there is now a great difference. In the case of the United States the excess of exports is accentuated by the export of capital from the superabundant wealth of the country; in the case of New Zealand the excess of exports is diminished by the continued import of capital, or by the borrowing of the colony and the continued inflow of outside capital.

The popular imagination is not so greatly impressed or so easily alarmed by an excess of exports as by an excess of imports;

but were it not for the continued borrowing the excess of exports would supply much food for reflection. During the period of sixteen years, 1887–1902, New-Zealanders have produced an excess of exports of £33,000,000. This represents fairly what they have produced but not enjoyed. The sum amounts to about £50 per head of the average population for the period. During the same period the public debt of the colony has increased by £20,000,000. Thus the result of the New-Zealanders denying themselves the use of thirty-three million pounds' worth of the produce of their industry during sixteen years has been merely to prevent the colony getting into debt by more than £20,000,000. It follows that during this period the amount due annually to residents abroad, chiefly for interest on loans and profits on investments, has averaged about £3,300,000, or over £3 a head of average population and £15 per family. This is the result of what has been, I believe, in the main a perfectly sound policy.

I mention these results merely as being interesting in themselves, and as a testimony to the resources of a colony that can be subject to such obligations and at the same time maintain its population in a state of such considerable comfort.

CONCLUSION.

In the foregoing we have not complicated the subject by taking into account changes in average prices. These have been pretty considerable during the whole period considered, and in some cases no valid conclusion can be drawn without taking them into account. I have considered, however, that they would make but very slight difference in the argument of this paper—not sufficient to compensate for the greater complexity their inclusion would induce.

ART. VIII. — *The Adjustment of Triangulation by Least Squares.—Part II.*

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EXAMPLE NO. 2.—THE ADJUSTMENT OF A POLYGON.

FOLLOWING the method adopted in example No. 1,* the usual adjustment as practised in New Zealand will be first de-

* Trans. N.Z. Inst., vol. xxxv., p. 201.

scribed, and then the least-square adjustment will be considered and the practical application of it explained.

In the figure the sides $P P_1$ and $P P_4$ are derived from the existing triangulation, and are to be adopted as correct both in bearing and distance. The triangulation is to be extended to include the stations P_2 and P_3, and to this end all the angles of the triangles are equally well observed. These observed angles are shown in column 2 of the schedule.

I. *The Ordinary Adjustment.*

The first correction to the observed angles consists in applying one-third of the triangular error in each triangle to each angle, and is shown in (3). The corrected centre angles are entered in (4) and added to the given angle $P_1 P P_4$, and the sum of these angles should be 360°. This is not usually the case, so the difference between the sum and 360° is distributed equally among the centre angles: thus each centre angle receives a further correction of $\frac{\epsilon_0}{i}$ where ϵ_0 = the difference between the sum of the angles in (4) and 360°, and i = the number of triangles. To keep the sum of the angles of each triangle equal to 180° it is necessary to apply half this correction to each of the base angles. These corrections are shown in (5), and the corrected angles appear in (6). This completes the adjustment of the centre angles, and the subsequent corrections affect the base angles only.

The length of the side $P P_4$ is calculated from $P P_1$ using the angles in (6)—the sines of these angles appear in (11)—and the length so obtained is compared with the true length. As the two values of $P P_4$ do not usually agree, a further correction to the base angles becomes necessary, and is found thus: If l = true length of $P P_4$ and l^1 = length of $P P_4$ calculated from $P P_1$, using the angles in (6), then $\epsilon = \frac{l - l^1}{l}$ radians. In (9) the cotangents of the base angles are given and the sum Σ (cot A + cot B) obtained. Then the correction to each base angle is $= \frac{\epsilon}{\Sigma (\cot A + \cot B)}$ radians.

The calculation of the correction is shown on the schedule, and gives 4″·06 in this example. In (7) the correction is applied, and the final angles appear in (8).

At this stage the work is checked by calculating $P P_4$ from $P P_1$, using the final angles in (8), and, as shown on the schedule, the calculated value of $P P_4$ agrees with the true value, thus proving the correctness of the work.

In (10) the value of 1″ for each of the base angles is given. The products of (7) and (10) give in (12) the corrections to be

applied to (11) to obtain the sines of the final angles shown in (13).

The corrections to the sines in (11) are shown in (12), and are equal to (7) × (10).

The triangles are now solved, using the final angles in (8), and the results are given in (15).

The bearings in (16) are obtained by applying the final angles in (8) to the given bearing of $P P_1$, checking on the bearing of $P P_4$.

The rectangular co-ordinates of P_2 and P_3 are calculated from the bearings and distances in (16) and (15).

This completes the adjustment of the polygon. It will be seen that all the geometrical conditions of the figure are completely satisfied, but, as will be shown subsequently, the corrections applied to the observed angles are considerably larger than those required by least squares. It will also be noticed that the centre angles are corrected independently of the side adjustment, which is thus not allowed to influence the adjustment of the centre angles in any way.

II. *The Least-square Adjustment.*

The application of this adjustment is given on the schedule. Columns (1), (2), (3), and (4) are the same as in the ordinary adjustment. The angles of the first computation in (5) are not corrected for the error of the centre angles, but are equal to (2) + (3). (9) contains the sines of (5), and with these sines the three triangles are solved, and the length of $P P_4$ obtained by calculation from $P P_1$.

Comparison of this value with the true value gives ϵ, while ϵ_0 is obtained from (4).

Column (10) gives a_1, b_1, c_1, &c., and $\Sigma (a^2 + b^2 + c^2)$; from this column $h = c_1 + c_2 + c_3$ and $2k = \frac{1}{3} \Sigma (a^2 + b^2 + c^2)$ are obtained.

The equations for P and Q are now formed and solved. With these values of P and Q the corrections to the observed angles are calculated, thus:—

$$\begin{array}{lll} x_1 = a_1 P - Q & x_2 = a_2 P - Q & x_3 = a_3 P - Q \\ y_1 = b_1 P - Q & y_2 = b_2 P - Q & y_3 = b_3 P - Q \\ z_1 = c_1 P + 2Q & z_2 = c_2 P + 2Q & z_3 = c_3 P + 2Q \end{array}$$

and the values are entered in column (6) and applied to the angles in (5), giving the final angles as shown in (7).

A check is obtained at this stage by noting that $P_1 P P_4 + C_1 + C_2 + C_3$ (from (7)) $= 360°$. (11) contains the sines of the angles in (7), and a check computation of $P P_4$ from $P P_1$ proves the correctness of the work.

The triangles are solved using the sines in (11), and the results given in (13). (14) contains the bearings obtained by

applying the final angles in (7) to the bearing of $P P_1$. The rectangular co-ordinates are obtained from the bearings and distances in (14) and (13).

III. *Comparison of Results.*

The corrections to the angles, after adjusting each triangle to 180°, are obtained from (5) and (7) of I., and are given below; the corresponding least-square corrections are also given.

Angles.	Ordinary Corrections = (5) + (7) of I.	Least-square Corrections = (6) of II.
	"	"
A_1	− 4·84	− 3·80
B_1	+ 3·29	− 0·17
C_1	+ 1·55	+ 3·97
A_2	− 4·84	− 3·14
B_2	+ 3·28	+ 2·17
C_2	+ 1·56	+ 0·97
A_3	− 4·84	− 4·10
B_3	+ 3·29	+ 4·38
C_3	+ 1·55	− 0·28
Total corrections irrespective of sign	29·04	22·98

In the angles C_1 and B_3 the least-square correction is larger than the ordinary correction; but the total corrections to all the angles of the figure are, by least squares, much less than those obtained in the ordinary way.

Thus, the total ordinary correction is ... ... 29"·04 or 9"·68 per triangle,
while the total least square is ... 22·98 „ 7·66 „
thus giving a difference of ... 6·06 „ 2·02 „
in favour of the least-square adjustment.

A comparison of the bearings and lengths shows the following differences:—

Side.	Bearings, Ordinary (from I.).	Least Square (from II.).	Differences.	Lengths, Ordinary (from I.).	Least Square (from II.).	Differences.
	° ′ ″	″	″	Links.	Links.	Links.
$P P_2$ ..	113 28 19·78	17·36	+ 2·42	96148·79	96148·54	+ 0·25
$P P_3$ ..	68 21 30·22	28·39	+ 1·83	73459·60	73459·02	+ 0·58
$P_1 P_2$ ..	59 27 54·95	51·49	+ 3·46	49764·48	49765·26	− 0·78
$P_2 P_3$ ..	343 3 50·06	46·53	+ 3·53	68352·69	68352·29	+ 0·40
$P_3 P_4$ ..	282 46 40·17	39·44	+ 0·73	61867·90	61867·06	+ 0·84

These differences in bearings and lengths result from the methods of adjustment adopted, and are entirely inde-

pendent of the observed angles, as the same observed angles have been used in each case. Each adjustment gives a consistent geometrical figure, and preference is given to the least-square adjustment because it gives this consistent figure with the least alteration to the observed angles, as shown in this example, and as would also appear by comparing any other process of adjustment therewith.

The notation used in the least-square adjustment is similar to that used in example No. 1, and is here repeated for convenience of reference.

Let l^1 = length of $P P_4$ calculated from $P P_1$, using the angles from (6) Schedule 1, (5) Schedule 2;

" l = true length of $P P_4$:

then $\epsilon = \dfrac{l - l^1}{l}$ radians

ϵ_0 = sum of angles at P (from (4)) − 360°

$a_1 = \cot A_1$

$\beta_1 = \cot B_1$

$a_1 = 2a_1 + \beta_1$

$b_1 = -a_1 - 2\beta_1$

$c_1 = -a_1 + \beta_1$

$2k = \frac{1}{3}\Sigma(a^2 + b^2 + c^2)$

$h = c_1 + c_2 + c_3$

i = the number of triangles.

The equations for P and Q are—

$$\left.\begin{aligned} h\,P + 2i\,Q + \epsilon_0 &= 0 \\ 2k\,P + h\,Q + \epsilon &= 0 \end{aligned}\right\}$$

The corrections to the angles are—

$$x_1 = a_1 P - Q$$
$$y_1 = b_1 P - Q$$
$$z_1 = c_1 P + 2Q, \text{ \&c.},$$

and are given in (6); and the corrected angles are—

$$A_1 + x_1$$
$$B_1 + y_1$$
$$C_1 + z_1, \text{ \&c.},$$

where the corrections are applied to the values of the angles in (5).

For the theory of the adjustment reference must be made to any of the treatises on least squares. The method here used is described by Colonel Clarke in his "Geodesy," but differs in the application of the triangular error, which is applied before the condition-equations are derived. This shortens the numerical work considerably, and thereby lessens the risk of numerical slips. As in the case of example No. 1, all the calculations have been performed on the Brunsviga calculating-machine.

Schedule No. 1.—Ordinary Computation of Polygon with Brunsviga Calculating-machine.

P P_1 side, 144° 30′ 46″, 78084·3 links; P P_4 side, 11° 1′ 36″, 41542·2 links.

	(1.) Ls.	(2.) Observed.	(3.) Corr.	(4.) Centre Ls.	(5.) Corr.	(6.) Angles of First Computation.	(7.) Corr.	(8.) Final Ls.	(9.) Cot.	(10.) Val. 1″.	(11.) Nat. Sines of (6).	(12.) Corr.	(13.) Final Sines of (8).	(14.) Sides.	(15.) Links.	(16.) Bearings.
		Adjustment of Angles.							Adjustment of Sides.							
		° ′ ″	″	° ′ ″	″	′ ″	″	′ ″								° ′ ″
P_1 P P_4				226 30 50·00												
A_1	...	54 0 29	+ 0·67	...	− 0·78	28·89	− 4·06	24·83	+ 0·726	+ 28·49	0·8090993	− 116	0·8090877	P P_1	78084·30	144 30 46·00
B_1	...	94 57 5	+ 0·66	...	− 0·77	4·89	+ 4·06	8·95	− 0·087	− 4·18	0·9962686	− 17	0·9962669	P P_2	96148·79	113 28 19·78
C_1	...	31 2 24	+ 0·67	31 2 24·67	+ 1·55	26·22	...	26·22	...	...	...	...	0·5156456	P_1 P_2	49764·48	59 27 54·95
		179 59 58														
A_2	...	85 17 47	− 2	...	− 0·78	44·22	− 4·06	40·16	+ 0·082	+ 3·98	0·9966311	− 16	0·9966295	...	...	...
B_2	...	49 35 29	− 2	...	− 0·78	26·22	+ 4·06	30·28	+ 0·851	+ 31·43	0·7614321	+ 128	0·7614449	P P_3	73459·60	68 21 30·22
C_2	...	45 6 50	− 2	45 6 48·00	+ 1·56	49·56	...	49·56	...	...	...	...	0·7085093	P_2 P_3	68352·69	343 3 50·06
		180 0 6														
A_3	...	88 15 0	+ 0·66	...	− 0·77	14 59·89	− 4·06	14 55·83	+ 0·031	+ 1·48	0·9995336	− 6	0·999 330	...	...	...
B_3	...	34 26 6	+ 0·67	...	− 0·78	5·89	+ 4·06	9·95	+ 1·459	+ 39·99	0·5652305	+ 163	0·5652468	P P_4	41542·20	11 1 36·03
C_3	...	57 19 52	+ 0·67	57 19 52·67	+ 1·55	54·22	...	54·22	...	...	...	...	0·8418098	P_3 P_4	61867·90	282 46 40·17
		179 59 58		359 59 55·34					+ 3·062							
				360 0 0·00												
			ϵ_0	= 0 0 4·66												

Sin A_1 sin A_2 sin A_3 (from column (11)) = 0·8059974,2
Sin B_1 sin B_2 sin B_3 (from column (11)) = 0·4287787,3

$$\frac{78084{\cdot}3 \times 0{\cdot}4287787{,}3}{0{\cdot}8059974{,}2} = \frac{41539{\cdot}695}{41542{\cdot}2}$$

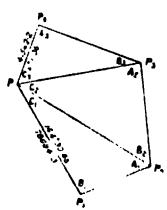
$$2{\cdot}505$$

$$\frac{2{\cdot}505 \times 206265}{41542{\cdot}2 \times 3{\cdot}062} = 4''{\cdot}062$$

Check from (13).

Sin A_1 sin A_2 sin A_3 = 0·8059841,0
Sin B_1 sin B_2 sin B_3 = 0·4287975,2

$$\frac{78084{\cdot}3 \times 0{\cdot}4287975{,}2}{0{\cdot}8059841{,}0} = 41542{\cdot}20{,}2$$



SCHEDULE No. 2. LEAST-SQUARE COMPUTATION OF POLYGON WITH BRUNSVIGA CALCULATING-MACHINE.

P P_1 side, 144° 30′ 46″, 78084·3 links; P P_4 side, 11° 1′ 36″, 41542·2 links.

(1.) Ls.	(2.) Observed.	(3.) Corr.	(4.) Centre Ls.	(5.) Angles of First Computation.	(6.) Corr.	(7.) Final Ls.	(8.)	(9.) Nat. Sines of (5).	(10.) a, b, and c.	(11.) Final Sines.	(12.) Sides.	(13.) Links.	(14.) Bearings.
	° ′ ″	″	° ′ ″	″	″	′ ″							° ′ ″
P P_1 P P_4			226 30 50·00										
A_1	54 0 29	+ 0·67		29·67	− 3·10	25·87	...	0·8091015	a_1 + 1·365	0·8010907	P P_1	78084·3	144 30 46
B_1	94 57 5	+ 0·66		5·66	− 0·17	5·49	...	0·9962680	b_1 − 0·552	0·9962080	P P_2	96148·54	113 28 17·36
C_1	31 2 24	+ 0·67		24·67	+ 3·97	28·64	...	...	c_1 − 0·813	0·5156556	P_1 P_2	49765·26	59 27 51·49
	179 59 58												
A_2	85 17 47	− 2		45·00	− 3·14	41·86	...	0·9966314	a_2 + 1·015	0·9966302	...	...	...
B_2	49 35 29	− 2		27·00	+ 2·17	29·17	...	0·7614346	b_2 − 1·784	0·7614414	P P_3	73459·02	68 21 28·39
C_2	45 6 50	− 2	48·00	48·00	+ 0·97	48·97	...	...	c_2 + 0·760	0·7085074	P_2 P_3	68153·29	343 3 46·53
	180 0 6												
A_3	88 15 0	+ 0·66	...	0·66	− 4·10	14 56·56	...	0·9995337	a_3 − 1·521	0·9995331	...	...	...
B_3	34 25 6	+ 0·67	...	6·67	+ 4·38	11·05	...	0·5652337	b_3 − 2·949	0·5652512	P P_4	41542·20	11 1 36·00
C_3	57 19 52	+ 0·67	52·67	52·67	− 0·28	52·39	...	...	c_3 − 1·428	0·8416050	P_3 P_4	61867·06	282 46 39·44
	179 59 54		55·34										
			60·00						$\Sigma(a^2 + b^2 + c^2)$ − + 20·682				
		ϵ_0 −	− 4·66										

Checks.

$\sin A_1 \sin A_2 \sin A_3$ (from (9)) = 0·8059999,5
$\sin B_1 \sin B_2 \sin B_3$ (from (9)) = 0·4287892,4

$$\frac{78084{\cdot}3 \times 0{\cdot}4287822{,}4}{0{\cdot}8059999{,}5} - 41539{\cdot}908 \quad 41542{\cdot}2 \quad + 2{\cdot}297$$

$$\therefore \epsilon = \frac{2{\cdot}297}{41542} = + 0{\cdot}00005529 \text{ radians} = + 11''{\cdot}40$$

$h = c_1 + c_2 + c_3 = + 1{\cdot}384$
$2k = \frac{1}{3}\Sigma(a^2 + b^2 + c^2) = + 6{\cdot}894$
$i = + 3$
$\epsilon_0 = - 4{\cdot}66$
$\epsilon = + 11{\cdot}40$

$$\therefore \begin{matrix} 1{\cdot}384\,P + 6\,Q - 4{\cdot}66 = 0 \\ 6{\cdot}894\,P + 1{\cdot}384\,Q + 11{\cdot}40 = 0 \end{matrix}$$

$\therefore P = - 1{\cdot}897$
$Q = + 1{\cdot}214$

(α) ° ′ ″
226 30 50·00 from (4).
28·64
48·97 from (7).
52·39
0·00

(β) $\sin A_1 \sin A_2 \sin A_3$ (from (11)) = 0·8059877,4
$\sin B_1 \sin B_2 \sin B_3$ (from (11)) = 0·4287993,9

$$\frac{78084{\cdot}3 \times 0{\cdot}4287993{,}9}{0{\cdot}8059877{,}4} = 41542{\cdot}198$$

[For diagram see Schedule 1.

Art. IX.—*On the Construction of a Table of Natural Sines by Means of a New Relation between the Leading Differences.*

By C. E. Adams.

[*Read before the Wellington Philosophical Society, 2nd November, 1904.*]

Part II.

1. To show the immense power of this method of obtaining the leading differences, an exceptional example is here given of the formation of a table of natural sines to twenty-four decimal places for every nine degrees of the quadrant.

The values of sin 9° and cos 9° are readily obtained from the series given in Part I.,* and are :—

$$\text{Sin } 9° = 0{\cdot}15643,\ 44650,\ 40230,\ 86901,\ 0105$$
$$\text{Cos } 9° = 0{\cdot}98768,\ 83405,\ 95137,\ 72619,\ 0040$$

To test these values they are squared, and give :—

$$\text{Sin}^2\ 9° = 0{\cdot}02447,\ 17418,\ 52423,\ 21394,\ 1780$$
$$\text{Cos}^2\ 9° = 0{\cdot}97552,\ 82581,\ 47576,\ 78605,\ 8219$$

hence the values are correct.

Now, $k = 2\,(1-\cos\Delta x) = 2\,(1-\cos 9°)$
$= 0{\cdot}02462,\ 33188,\ 09724,\ 54761,\ 99195.$

The leading differences are formed as described in Part I., and a convenient working schedule is arranged thus :—

Tabular interval = $\Delta x = 9°$

$\sin 0°$	$= 0{\cdot}00000,\ 00000,\ 00000,\ 00000,\ 0000$
$\Delta \sin 0°$	$= +\ 0{\cdot}15643,\ 44650,\ 40230,\ 86901,\ 0105$
$\sin 9° = \sin 0° + \Delta \sin 0°$	$= +\ 0{\cdot}15643,\ 44650,\ 40230,\ 86901,\ 0105$
$\Delta^2 \sin 0° = -\,k\,.\,\sin 9°$	$= -\ 0{\cdot}00385,\ 19357,\ 05514,\ 31391,\ 79172$
$\Delta \sin 9° = \Delta \sin 0° + \Delta^2 \sin 0°$	$= +\ 0{\cdot}15258,\ 25293,\ 34716,\ 55509,\ 2188$
$\Delta^2 \sin 0° = -\,k\,.\,\Delta \sin 9°$	$= -\ 0{\cdot}00375,\ 70882,\ 64602,\ 87371,\ 61559$
$\Delta^2 \sin 9° = \Delta^2 \sin 0° + \Delta^3 \sin 0°$	$= -\ 0{\cdot}00760,\ 90239,\ 70117,\ 18763,\ 40731$
$\Delta^4 \sin 0° = -\,k\,.\,\Delta^2 \sin 9°$	$= +\ 0{\cdot}00018,\ 73594,\ 23047,\ 03150,\ 04117,\ 13$
$\Delta^3 \sin 9° = \Delta^3 \sin 0° + \Delta^4 \sin 0°$	$= -\ 0{\cdot}00356,\ 97288,\ 41555,\ 84221,\ 57442$
$\Delta^5 \sin 0° = -\,k\,.\,\Delta^3 \sin 9°$	$= +\ 0{\cdot}00008,\ 78985,\ 71329,\ 89818,\ 89906,\ 78$
$\Delta^4 \sin 9° = \Delta^4 \sin 0° + \Delta^5 \sin 0°$	$= +\ 0{\cdot}00027,\ 52579,\ 94376,\ 92968,\ 94023,\ 91$
$\Delta^6 \sin 0° = -\,k\,.\,\Delta^4 \sin 9°$	$= -\ 0{\cdot}00000,\ 67777,\ 65350,\ 46850,\ 65814,\ 220$

* Trans. N.Z. Inst., 1902, p. 409–10.

$\Delta^5 \sin 9° = \Delta^5 \sin 0° + \Delta^6 \sin 0° = + 0{\cdot}00008, 11208, 05979, 42968, 24092, 56$

$\Delta^7 \sin 0° = - k \,.\, \Delta^5 \sin 9° = - 0{\cdot}00000, 19974, 63467, 73330, 64528, 5908$

$\Delta^6 \sin 9° = \Delta^6 \sin 0° + \Delta^7 \sin 0° = - 0{\cdot}00000, 87752, 28818, 20181, 30342, 811$

$\Delta^8 \sin 0° = - k \,.\, \Delta^6 \sin 9° = + 0{\cdot}00000, 02160, 75256, 81886, 56155, 99392$

$\Delta^7 \sin 9° = \Delta^7 \sin 0° + \Delta^8 \sin 0° = - 0{\cdot}00000, 17813, 88210, 91444, 08372, 5969$

$\Delta^9 \sin 0° = - k \,.\, \Delta^7 \sin 9° = + 0{\cdot}00000, 00438, 63689, 84123, 11107, 46185$

$\Delta^8 \sin 9° = \Delta^8 \sin 0° + \Delta^9 \sin 0° = + 0{\cdot}00000, 02599, 38946, 66009, 67263, 45577$

$\Delta^{10} \sin 0° = - k \,.\, \Delta^8 \sin 9° = - 0{\cdot}00000, 00064, 00559, 55467, 55455, 96711, 3$

This exhibits the complete working necessary to obtain the leading differences up to $\Delta^{10} \sin 0°$. As will be seen from the schedule above, the only operations are addition and multiplication. Each multiplication was done to the full extent as shown above on the Brunsviga calculating-machine without any intermediate record, and each multiplication was checked by doing it in duplicate: thus, to obtain $k \,.\, \sin 9°$, k was first set on the machine and multiplied by $\sin 9°$, then $\sin 9°$ was set on the machine and multiplied by k, and no result was accepted unless every figure to the last agreed in each case.

Having now obtained the leading differences and the initial term ($\sin 0°$), the table is formed in the usual way, with the following results:—

	Sines.	Corrections.
0°	0·00000, 00000, 00000, 00000, 0000	
9°	0·15643, 44650, 40230, 86901, 0105	
18°	0·30901, 69943, 74947, 42410, 2293	
27°	0·45399, 04997, 39546, 79156, 0408	
36°	0·58778, 52522, 92473, 12916, 8706	
45°	0·70710, 67811, 86547, 52440, 0845	− 1
54°	0·80901, 69943, 74947, 42410, 2295	− 2
63°	0·89100, 65241, 88367, 86235, 9712	− 3
72°	0·95105, 65162, 95153, 57211, 6443	− 4
81°	0·98768, 83405, 95137, 72619, 0045	− 5
90°	1·00000, 00000, 00000, 00000, 0006	− 6

The last value is 6 in excess in the twenty-fourth decimal place; comparing the value of $\sin 81°$ with $\cos 9°$ as found direct from the series it is seen that this value is 5 in excess; and comparing $\sin 54°$ with $\sin 18°$ the former is 2 in excess: hence it seems reasonable to adjust these values by deducting 1, 2, 3, 4, 5, and 6 from $\sin 45°$, $\sin 54°$, $\sin 63°$, $\sin 72°$, $\sin 81°$, and $\sin 90°$.

2. As the tabular interval becomes smaller the value of k is reduced, with a corresponding reduction in the labour of forming the leading differences. Thus in the formation of a table of sines for every degree we have, from the series in Part I.,—

$$\sin 1^\circ = 0{\cdot}01745,\ 24064,\ 37283,\ 51281,\ 94189,\ 78$$
$$\cos 1^\circ = 0{\cdot}99984,\ 76951,\ 56391,\ 23915,\ 70115,\ 59$$

The squares of these are :—

$$\sin^2 1^\circ = 0{\cdot}00030,\ 45864,\ 90452,\ 13499,\ 68782,\ 7997$$
$$\cos^2 1^\circ = 0{\cdot}99969,\ 54135,\ 09547,\ 86500,\ 31217,\ 20$$

hence sin 1° and cos 1° are correct,* and $k = 2\,(1-\cos 1^\circ) = 0{\cdot}00030$, &c.

The working schedule for the formation of the leading differences is accordingly as follows :—

Tabular interval $= \Delta x = 1^\circ$

$k = \quad 0{\cdot}00030,\ 46096,\ 87217,\ 52168,\ 59768,\ 818$

$\sin 0^\circ = \quad 0{\cdot}00000,\ 00000,\ 00$

$\Delta \sin 0^\circ = + 0{\cdot}01745,\ 24064,\ 373$

$\sin 1^\circ = \sin 0^\circ + \Delta \sin 0^\circ = + 0{\cdot}01745,\ 24064,\ 37$

$\Delta^2 \sin 0^\circ = -k \,.\, \sin 1^\circ = - 0{\cdot}00000,\ 53161,\ 721$

$\Delta \sin 1^\circ = \Delta \sin 0^\circ + \Delta^2 \sin 0^\circ = + 0{\cdot}01744,\ 70902,\ 652$

$\Delta^3 \sin 0^\circ = -k \,.\, \Delta \sin 1^\circ = - 0{\cdot}00000,\ 53145,\ 5271$

$\Delta^2 \sin 1^\circ = \Delta^2 \sin 0^\circ + \Delta^3 \sin 0^\circ = - 0{\cdot}00001,\ 06307,\ 248$

$\Delta^4 \sin 0^\circ = -k \,.\, \Delta^2 \sin 1^\circ = + 0{\cdot}00000,\ 00032,\ 38222$

$\Delta^3 \sin 1^\circ = \Delta^3 \sin 0^\circ + \Delta^4 \sin 0^\circ = - 0{\cdot}00000,\ 53113,\ 1449$

$\Delta^5 \sin 0^\circ = -k \,.\, \Delta^3 \sin 1^\circ = + 0{\cdot}00000,\ 00016,\ 17877,\ 8$

&c.

With these leading differences the table may be constructed up to 60°, or to 90° if preferred; however, unless the work is carried out to considerably more decimal places than are here shown the final figures of the higher values will not be accurate.

It seems preferable, therefore, to construct the table in sections, 0°–9°, 9°–18°, 18°–27°, &c.

The values of sin 9°, sin 18°, &c., are obtained from 1 above, and the formation of the table for the section 9°–18° will then proceed as follows :—

---

* See the value of sin 1° in Logarithmic Tables, R. Shortrede—
sin 1° = 0·01745, 24064, 17275, 54
which is 0·00000, 00000, 20007, 97 in error.

Tabular interval $= \Delta x = 1°$. Initial value sin 9°.

$k = 0{\cdot}00030$, &c.

Now, $\Delta \sin 9° = \cos 9° \sin 1° - \frac{k}{2} \cdot \sin 9°$

$= 0{\cdot}01721$, &c.

Section 9°–18°.

$\sin 9°$	$= + 0{\cdot}15643, 44650, 40$
$\Delta \sin 9°$	$= + 0{\cdot}01721, 37126, 267$
$\sin 10° = \sin 9° + \Delta \sin 9°$	$= + 0{\cdot}17364, 81776, 67$
$\Delta^2 \sin 9° = - k \sin 10°$	$= - 0{\cdot}00005, 28949, 1709$
$\Delta \sin 10° = \Delta \sin 9° + \Delta^2 \sin 9°$	$= + 0{\cdot}01716, 08177, 096$
$\Delta^3 \sin 9° = - k \Delta \sin 10°$	$= - 0{\cdot}00000, 52273, 51315$
$\Delta^2 \sin 10°$	$= - 0{\cdot}00005, 81222, 6840$
$\Delta^4 \sin 9° = - k \Delta^2 \sin 10°$	$= + 0{\cdot}00000, 00177, 04606, 0$
$\Delta^3 \sin 10°$	$= - 0{\cdot}00000, 52096, 46709$
$\Delta^5 \sin 9°$	$= + 0{\cdot}00000, 00015, 86908, 85$
$\Delta^4 \sin 10°$	$= + 0{\cdot}00000, 00192, 91514, 9$
$\Delta^6 \sin 9°$	$= - 0{\cdot}00000, 00000, 05876, 382$

&c.

These leading differences are sufficient to determine the sines to twelve places of decimals, the value obtained for sin 18° being 0·30901, 69943, 75, which checks the work; and the other values, as taken from the working schedule without any alteration or adjustment, are:—

	Sines.		Sines.
9°	0·15643, 44650, 40	14°	0·24192, 18956, 00
10°	0·17364, 81776, 67	15°	0·25881, 90451, 03
11°	0·19080, 89953, 77	16°	0·27563, 73558, 17
12°	0·20791, 16908, 18	17°	0·29237, 17047, 23
13°	0·22495, 10543, 44	18°	0·30901, 69943, 75

3. The next example selected is where the tabular interval is 3′, and values approximately correct to eleven decimal places are required.

Tabular interval $= \Delta x = 3'$. Initial value 9°.

$\sin 3' = 0{\cdot}00087, 26645, 15235, 14954, 3304$ From series in Part I.

$\cos 3' = 0{\cdot}99999, 96192, 28249, 43113, 77097$ From series in Part I.

$\therefore k = 0{\cdot}00000, 07615, 43501, 13772, 45806$

also $\Delta \sin 9° = \cos 9° \sin 3' - \frac{k}{2} \sin 9°$

$= 0{\cdot}00086, 18610, 01$

Section 9° 0′ – 10°.

$\sin 9°$ = + 0·15643, 44650, 4

$\Delta \sin 9°$ = + 0·00086, 18610, 01

$\sin 9° 3'$ = + 0·15729, 63260, 4

$\Delta^2 \sin 9° = -k . \sin 9° 3'$ = − 0·00000, 01197, 880

$\Delta \sin 9° 3' = \Delta \sin 9° + \Delta^2 \sin 9°$ = + 0·00086, 17412, 13

$\Delta^3 \sin 9° = -k . \Delta \sin 9° 3'$ = − 0·00000, 00006, 5625

&c.

Sections of 1° each (0°–1° ; 1°–2° ; &c.) are formed thus, and the values found in 2 above are used to check each terminal value.

Thus for the section 9° 0′ – 10° the sines are :—

°	′	Sines.	
9	0	0·15643, 44650, 4	
	3	0·15729, 63260, 4	
	6	0·15815, 80672, 5	
.	. .	. . . . .	
	54	0·17192, 91003, 8	
	57	0·17278, 87047, 7	
10	0	0·17364, 81776, 7	
10	0	0·17364, 81776, 67	check value.

4. Finally we have the case of a 10″ table to seven decimals.

Tabular interval = $\Delta x = 10''$. Initial value, 9° 54′.

$\sin 10''$ = 0·00004, 84813, 68092, 4

$\cos 10''$ = 0·99999, 99988, 24778, 473

k = 0·00000, 00023, 50443, 053

$\Delta \sin 9° 54' = \cos 9° 54' . \sin 10'' - \frac{k}{2} \sin 9° 54'$

= 0·00004, 77592, 458

Section 9° 54′ – 9° 57′.

$\sin 9° 54'$ = + 0·17192, 91003

$\Delta \sin 9° 54'$ = + 0·00004, 77592, 458

$\sin 9° 54' 10''$ = + 0·17197, 68595

$\Delta^2 \sin 9° 54' = -k . \sin 9° 54' 10''$ = − 0·00000, 00004, 04221, 8

$\Delta \sin 9° 54' 10''$ = + 0·00004, 77588, 416

$\Delta^3 \sin 9° 54' = -k . \Delta \sin 9° 54' 10''$ = − 0·00000, 00000, 00112,

254 &c.

These leading differences are sufficient to determine the sines to ten decimal places approximately; and for this particular section the value of sin 9° 57′ is 0·17278, 87047, 6,

while the value obtained in 3 above is 0·17278, 87047, 7, which sufficiently checks the work.

The results may then be safely cut down to seven decimals, and will give the sines correct in the last figure, except perhaps in a few cases where the 8th, 9th, and 10th decimals are 499, 500, or 501.

Thus in the section under construction the final values are:—

°	′	″	Sines.	Proportional Parts.	
9	54	0	0·171 9291		
		10	171 9769		
		20	172 0246		
		30	172 0724		
		40	172 1201	″	
		50	172 1679	1	47·8
	55	0	0·172 2156	2	95·5
		10	172 2634	3	143·3
		20	172 3112	4	191·0
		30	172 3589	5	238·8
		40	172 4067	6	286·5
		50	172 4544	7	334·3
	56	0	0·172 5022	8	382·0
		10	172 5499	9	429·8
		20	172 5977		
		30	172 6454		
		40	172 6932		
		50	172 7410		
	57	0	0·172 7887		

The mark under a figure, thus $\underline{2}$, in sin 9° 56′ 40″. indicates that the figure so marked has been increased by 1 to compensate for the figures cut off, the full value in this instance being 0·17269319964.

Art. X.—*Notes on some Bronze Buddhas from Pekin.*

By William Welch.

[*Read before the Manawatu Philosophical Society, 15th September,* 1904.]

These few notes on the bronze Buddhas are submitted with a large amount of diffidence, in that in a small country town such as Palmerston North we find a difficulty in consulting works of reference, and we are not so sure of our facts as we should be. In fact, we too often have to trust to memory from past reading.

These Buddhas form part of a collection that was looted from the Imperial Palace in the forbidden City of Pekin at the time of the relief of the legations by the allied troops, in August, 1899. I might say I have indisputable proof of genuineness of the statement that they came from the Imperial Palace, and not from the bazaars—for the bazaars were also looted, and they contained a lot of bronzes and other curios manufactured for sale to tourists as the genuine article, and no doubt much that came from Pekin bazaars at that time was sold as genuine. But these have a better history. I have a letter from the trooper of the New South Wales naval contingent who looted it. The naval people could bring away more plunder than the land forces, on account of the stowage-capacity of their boats; but a better proof is the fact that some of the bronzes contained a large percentage of gold, in some as much as 50 per cent., while in another was hidden a number of invocations to Buddha, block-printed, in the Tibetan language, on parchment (some were written), invocations in his attribute of Guardian Deity and Thunderbolt Bearer, sent by the Lama of Lhassa to the Emperor of China in the seventeenth century. These have been translated and examined by the Keeper of Oriental Manuscripts in the British Museum.

The way they were discovered—that is, the manuscripts—is rather amusing. My wife was reading some tale of Indian treasures, and remarked that it was a pity I could not find some large diamonds or emeralds in my Buddhas. I said "Yes, it is a pity." But the next morning I was gloating over them as usual, and I took up one and shook it, and sure enough I fancied I could hear a rustle. I tried again and again, still I could hear it. I was not sure whether it was my shirt-cuff, or my heart that was beating, for I may say I felt pretty excited. I examined the bronze carefully, and at last made out a small crack in the bottom. It was a different Buddha from the others: whereas the others were elaborately dressed and decorated, this one was specially plain—merely a sheet-like garment thrown over one shoulder, reaching to below the knees, and

a very plain head-covering; moreover, the image was gilded. But I worked away at this crack, and got a knife in, and at last wrenched open a piece that had been pinched in, and discovered sixteen very tightly rolled parchments. I wanted to know all about the writing then, but no one had ever seen such caligraphy before, so at last I sent a photo. to the British Museum, and they translated those I sent, as I have mentioned. I hope some day to say more about this Tibetan Buddha; but I think you will agree with me that after that there is no reason to doubt the trooper's statement that he looted them from the Palace.

I made the remark just now that there were some bronzes containing a large percentage of gold in their composition. This was done to give the finish and colour, or patina, to the article. Gold and silver are known to exist in more or less quantities in all old Chinese bronzes, but the art of mixing is lost.

I should say here, perhaps, what bronze is. It is essentially a mixture or compound of copper and tin, which metals appear to have been the earliest known. Neither of these metals possesses the hardness required for making instruments, either for domestic or warlike purposes, and they appear to have been early found capable of hardening each other by combination, consisting of different proportions according to the purposes to which it is to be applied. Bronze is always harder and more fusible than copper: it is highly malleable when it contains a very large proportion of copper, while tempering increases its malleability, and it oxidizes very slowly even in moist air: hence its application to so many purposes.

Mr. Fox, Professor of Egyptology at Oxford, I think, two or three years ago wrote a pamphlet on the ancient Egyptian tools, and he tells how they cut open a stone that had been partly sawn through and found imbedded the corrundrum teeth of a circular saw of bronze. Of course there was only the oxide left, but the teeth were intact, as well as the marks on the stone of the circular saw. The method of case-hardening bronze has been lost for many ages.

In the bronzes before us strength and hardness were evidently not a desideratum—only beauty of colour, and malleability to run while molten into every crevice of the mould; but though our chemists can find to a fraction the quantity of the various metals, they cannot find the secret of the mixing. Perhaps it was like the mixing of the Bessemer steel: at a certain temperature manganese is put into the molten iron, which causes the grain or texture to break up into finer particles and lay closer. This is steel by the Bessemer process instead of

by the old and expensive way of recarbonizing the iron. The analysis would not show the presence of the manganese, and the art of mixing for Bessemer steel could easily become one of the lost arts. It is imagined something of the kind occurred in the mixing of the ingredients of the ancient Chinese bronzes. For ornamental objects only beauty would be considered, and the value of the metals would not enter into the matter—only what would give the finest results—I mean whether they put in much or little of the precious metals.

In the two images of Buddha we have before us you will notice there is a complete absence of tool-marks—in fact, it is, I think, safe to say no tool has been near them. They appear exactly alike at first glance, as though they had come out of the same mould; but on a closer examination there are seen differences innumerable, and it is a tribute to the beautiful workmanship of the Chinese artisans that they should appear so nearly exact as to deceive one. Their method of making a casting was this: The pattern was first made in wax over a core—that is, the wax was the thickness of the metal required—and was then given its exact and beautiful finish; it was afterwards put in a plaster or clay mould, and when that was set a hole was made through the plaster into the wax, and then put into a heated oven: the wax ran out and left the mould empty. The core was held in place by stays of iron wire. After cooling, the molten metal was poured in, and the mould had to be smashed to get the figure. This process was known as *cire perdu* (lost wax). You thus see that only one impression was possible, and to make another the whole process had to be gone over again—the wax pattern to be made afresh, and the plaster mould. It was expensive, but the result was beautiful. In the present day castings are never made in one piece, but in several, which are afterwards united by heating and the application of fused metal.

Most representations of Buddha are as we see these—cross-legged, with the soles of the feet turned up. Sven Hedin, perhaps the greatest traveller in Tibet, speaking of the great seated Buddha of Lhassa, says he is seated European fashion—that is, with his legs down. This is the reincarnated Buddha, and the tradition is suggestive, and appeals to us more than perhaps any other Buddhist legend—that the end of the present age will be in the hands of the Pilings or western foreigner. There have been twenty-four legendary Buddhas who immediately preceded Gautama, and the next is the Europeanised Buddha who is thus shown in the fashion of western civilisation.

The word "Buddha" is always used in the ancient Pali texts as a title, not as a name, and means "enlightened." The

historical Buddha (the Gautama) taught that he was one of a long series of Buddhas who appear at intervals in the world, and all teach the same doctrines. After the death of each Buddha his religion flourishes for a time and then decays, and is at last completely forgotten, until a new Buddha appears, who again preaches the lost truth (or Dharma). The next Buddha will be Maitraya Buddha, "the Buddha of Kindness." In many he is holding the urn of wisdom. At a future time I would like to have more to say on the subject; I would only observe now that it seems somewhat strange in all cases I have come across the urn is made of a different piece of metal, and fits into the hands by a pin. It cannot be on account of the difficulty of casting, for I have seen some far more intricate; in fact, I have some bronzes myself from Japan that are so beautifully made that the idea of its being beyond the skill of the old Chinese masters to make the urn in one piece with the Buddha is not to be thought of. Probably it was done so that the urn may be taken out on certain occasions and something else put in. All the ornamentation has its uses and reasons, in the same way as the prescribed dress of the Jewish priesthood, or our Catholic and Episcopal clergy.

Some day a paper might be read on the Buddhist dress; but this present paper was merely intended to be a few notes on the making of an image of Buddha and the methods of casting.

ART. XI.—*Notes on Marsland Hill.*

By W. H. SKINNER, New Plymouth.

[*Read before the Manawatu Philosophical Society, 15th September,* 1904.]

PREFATORY REMARKS.

THERE is probably no spot in New Plymouth and its neighbourhood that the memories of the earlier pioneer and his children so universally cling to as Marsland Hill, as in the days of the fierce struggle, when British supremacy practically hung in the balance, this spot was their city of refuge: hallowed in no small degree by the old stone church at its base, which for nearly sixty years has been the silent witness of the din of battle as well as the blessings of peace, whilst on its sombre walls inside are hung mementoes of regiments taking part in the turmoil of those stormy days of long ago. Here also sleep many of the heroes who fell, and the lonely graves of these brave men bring back to mind deeds of valour, many of which are almost forgotten, or at any rate find no place in the pages of history.

Notes on the History of Marsland Hill.

During the stirring times and incidents of the early colonial days, especially whilst the interracial wars were in active progress, several localities became noted or remarkable from various causes.

After the first period of immediate activity and excitement terminated, all thoughts and energies were directed towards settling down and resuming in peace and quietness the previously interrupted pursuits and occupations. Among the actual participants, the elders who had again turned the sword into the ploughshare willingly and rapidly allowed the "sponge of oblivion" to wipe from the "slate of memory" the prominence of localities and incidents. Years have rolled on, and now that the second or third generations would like to have a complete history of the doings of those times it is found difficult to obtain reliable information—death and changes of location having removed so many of those who were its contemporaries—whilst documentary evidence is scarce, scattered, and meagre in detail. In this relation it is deemed advisable when definite information becomes available to take advantage of the same, and put it on actual record for the benefit of the rising generation and future historians.

The subject-matter of the present notes—namely, Marsland Hill, but originally called by the Maori inhabitants Pu-kaka—is a prominent hill in the heart of the town, situated immediately at the back of the Anglican Church of St. Mary's, and formerly rising to an altitude of about 220 ft. above sea-level.

During searches in the strong-room of the District Lands and Survey Office at New Plymouth, a plan, drawn from surveys by one of the Royal Engineer officers, delineating the old stockade, barracks, &c., erected on top of the said hill by Her Majesty's regular forces, was discovered.

Pu-kaka was an ancient Maori *pa*, and by oral evidence collected from the older Maoris is stated to have been first partly constructed by the Potiki-taua people, a branch of the Taranaki Tribe, for the purpose of resisting a threatened attack from the north. After the Potiki-taua were driven out of this part of Taranaki by the Ngatiawa, these latter completed the works, and occupied for a time this splendid specimen of an old Maori stronghold, as it existed prior to 1855. There is no account extant of Pu-kaka having been attacked or of its occupants sending parties forth on warlike expeditions, and it has therefore but little historical record previous to the military occupation in 1856. Puke-ariki, or Mount Eliot (also within the boundaries of New Plymouth Town), although of far less commanding position, seems to have quite overshadowed it in importance as a

"fighting" Maori stronghold. We are told that in or about the year 1805 scouts posted on Pu-kaka warned the people in Puke-ariki of the approaching war-party of Taranaki, which resulted in a sanguinary fight around the south-western base of this hill. (See "Journal of Polynesian Society," vol. ii., p. 179.) The *pa* was abandoned as a fortified spot by the Maoris about 1830. This seems to cover its pre-European-occupation history.

When the surveyors of the Plymouth Company, Messrs. F. A. and G. Carrington, started the survey of the Town of New Plymouth in 1841, Pu-kaka was covered with a beautiful growth of karaka, rewarewa, rangiora, kohekohe, and similar native trees; and they state that at its northern base (where now stands the church before mentioned) flourished one of the most beautiful karaka groves it was possible to imagine. Such was the condition of the hill up till the time the Imperial authorities cleared its slopes, levelled its summit, and occupied it as a military post.

The present name of "Marsland Hill" has no historical meaning or application. At the urgent request of Captain Liardet, R.N., who was the first resident agent of the Plymouth Company in New Plymouth, the then Chief Surveyor, Mr. F. A. Carrington, gave it the name "Marsland" after a great personal friend of Captain Liardet's.

One of the earliest pioneers of this district, Mr. Charles Brown, sen. (a friend and contemporary of Lord Byron and Mr. Keats), was buried on the northern slope of the hill in June, 1842, a large slab of stone being placed over his grave. This site was a favourite resort, but when the hill was escarped and fortified this rude memorial was covered with earth, and its exact locality is now lost.

In September, 1854, owing to the unsettled state of the district caused by the Puketapu feud and intertribal native war raging at Bell Block, detachments of the 58th and 65th Line Regiments were sent to New Plymouth from Auckland and Wellington, and in the following year barracks of strong galvanised iron were erected upon Marsland Hill. These barracks were brought over from Melbourne, Victoria, in which colony they had been used for the accommodation of the troops assisting in the repressive measures taken at the time of the Ballarat riots.

To provide the necessary room for erection of the barracks and stockade round same the top and several other parts of the hill were excavated and levelled, thus decreasing the altitude of the hill some 40 ft. While these works were in progress a coffin was found containing a human skeleton with portions of fair hair adhering to the skull; from the buttons and fragments of

clothing the remains were considered to be those of some naval officer who had been brought ashore for burial, but no record seems to exist of any such incident. From apparent age of the coffin it was judged that the interment took place long previous to the advent of the earliest settlers, or probably even to that of the desultory residence of the few whalers who occasionally frequented the district.

After the erection of the barracks they were first occupied in 1856 by a detachment of the 65th Regiment. A copy of the *Herald*, published on 22nd March, 1856, says: "The whole of the troops in New Plymouth now occupy the barracks on Marsland Hill, where the magazine has also been removed. A strong stockade, which is intended to surround the barracks, is in course of erection, and will add materially to the defensive capabilities of the position, although it is to be regretted that the view of the building from the surrounding neighbourhood will be in a great measure destroyed by it." An extract from the same paper published on the 12th January, 1856, says: "On Friday evening, the 28th December, the sergeants of the 65th gave a farewell ball to their brothers of the 58th in the barracks on Marsland Hill. The room was gaily decorated with military trophies, the colours of Britain and France waving amicably side by side. Several inhabitants of New Plymouth were present, and the evident cordiality existing between them and the military gave a zest to the entertainment of the evening."

The 65th occupied the barracks until the outbreak of the war between the colonists and the Maoris in March, 1860. From that date to January, 1870, they were occupied by detachments of the following regiments: Royal Artillery, Royal Engineers, 40th, 12th, 14th, 43rd, 57th, 50th, 68th, 70th, and 18th Line Regiments and Land Transport Corps. The Royal Marine L.I. were stationed at Fort Niger and Mount Eliot.

During this time, in the event of a threatened attack on the town or its neighbourhood, it was arranged that warning should be given by the firing of two rounds from the 32-pounders in a position on Marsland Hill; at this signal, like a hen gathering her chickens, so all the non-combatants, women, and children were to take refuge in the barracks, whilst the Militia and Volunteers within a circle of two miles were to rush into town and hold themselves in readiness to meet any such attack. Many of the now middle-aged residents relate how, when little children, and the alarm was thus sounded, they, with a gathering of the most valuable and portable of the Lares and Penates of their parents' homes, were bodily carried to their refuge. In a little work published in 1861, called "Settlers and Soldiers," the author thus describes such a scene: "Immediately after the dreadful boom-

ing of the report a stream of women and children were to be seen hurrying up the steep path into the barracks, for full ten minutes. Some women with a child under each arm, without either hat, bonnet, or shawl, some with a bundle hastily thrown together, and many seemed utterly bewildered amidst the confusion and noise of women crying, children screaming, and the eager, anxious questions to know what it was all about." Luckily, though "wolf" was often cried, the wolf, different from the one in the fable, never came, as no definite attack was ever made upon the town itself.

In 1874 the barracks were converted into an immigration depot, and continued to be used in this capacity for some years. In 1891 this historic building was condemned by the Defence Department as being no longer required. One wing was given to the North Egmont Forest Board, with a view to its being erected on the northern slope of Mount Egmont for the accommodation of tourists and others visiting the mountain. This has been done, and the house now stands at an elevation of about 3,140 ft., and is annually visited by hundreds of people from all parts of New Zealand and elsewhere. The main portions of the barracks were sold in lots to farmers.

II.—ZOOLOGY.

Art. XII.—*Additions to the Marine Mollusca of New Zealand.*

By R. Murdoch.

[*Read before the Wellington Philosophical Society, 2nd November*, 1904.]

Plates VII. and VIII.

Some few months ago I received from Mr. A. Hamilton, Director of the Colonial Museum, an interesting parcel of small and minute shells, which had been obtained by beach-gatherings at Whangaroa Harbour. This collection, though small in bulk, proves exceedingly rich in species. None of the larger forms are represented, and very few of those of medium size: it must therefore be regarded as little more than a tithe of the molluscan life of this northern locality. Several forms hitherto only recorded from Foveaux Strait and Stewart Island make their appearance, some of them in fair abundance.

In addition to the species recorded in the appended list, there are several which I have been unable to identify. Some of them may prove to be undescribed; others, again, are in too worn and damaged a condition — these include *Bittium*, *Colina*(?), and *Triphora*. Of the latter genus three species are represented, one of which has certainly not been recorded from New Zealand waters; it is little more than a fragment, but characterized by its four smooth spiral keels. Of *Cryptodon flexuosum*, Mont., a single valve occurs. The species is represented in the Colonial Museum collections by a number of separate valves, but the exact locality does not appear to have been given. Most probably they are from Stewart Island, as Captain Hutton records *Cryptodon*, sp. ind., from that locality.* The genus does not appear to have been again recognised, and in the "Manual of the New Zealand Mollusca," page 223, is rejected from the list.

The identification of many of our marine shells, perhaps more especially the smaller forms, is decidedly difficult. There is an absence of figures, and the descriptions, unfortunately, are exceedingly brief.

My best thanks are due to Captain Hutton, Mr. Henry Suter, of Auckland, and Mr. Charles Hedley, of the Australian Museum, for much valuable assistance.

* Cat. Marine Moll. N.Z., p. 75.

Cylichna striata, Hutton. Figs. 1, 2.

Cylichna striata, Hutton, Cat. Marine Moll. N.Z., p. 52 (1873); Cat. Tertiary Moll. and Echin. N.Z., p. 16; Manual N.Z. Moll., p. 120; Trans. N.Z. Inst., vol. xviii., p. 346. *C. arachis*, Hutton, "Macleay Memorial Volume," p. 37 (not of Quoy and Gaimard). *C. striata*, Hutton, "Index Faunæ Novæ-Zealandiæ," p. 69 (not *striata*, Pilsbry, Man. Conch. (1), vol. xv., p. 319, pl. 59, figs. 11, 12).

The types of this species are in the Colonial Museum. I have been unable to examine them, but Mr. C. Freyberg kindly did so at my request. They appear to be in good condition, sculptured with longitudinal growth-periods distinctly marked, but a total absence of spiral striæ; in fact, agree perfectly in all characters with the Whangaroa Harbour examples, of which there is a good series.

Pilsbry, when dealing with the specimens he had received from New Zealand, evidently had some doubts as to whether they were the true *striata*, remarking that the measurements given by Hutton indicated a much smaller form than his specimens. In addition to the larger size of his specimens, the measurements prove that they were of a more narrow, slender form. I have no doubt they were *C. arachis*, Quoy and Gaimard, with which the description agrees very well indeed. Examples of the latter species from New Zealand (I have only seen two) appear to be rather more minutely spirally striate than those from Port Jackson.

The figures and following description of *C. striata* is derived from the Whangaroa specimens: Shell short, subcylindrical, thin and white; last half-volution with a lightly concave appearance, more noticeable on approaching the lip. Sculptured with numerous well-marked longitudinal growth-periods, irregularly spaced. The crown concave, with a deep and moderately broad axial perforation. Aperture as long as the shell, narrow above, expanded and effuse below; the inner wall with a very thin callus. Columella thickened, slightly twisted, anteriorly rapidly declining, giving it an almost truncated appearance. In the juvenile stages the columella is usually more gently sloping; the crown with the same crater-like concavity, but the axial perforation shallow; the outer lip almost straight. Dimensions of largest specimen: Length, 3·8 mm.; breadth, 1·87 mm.

It is perhaps nearest to *C. pygmæa*, A. Adams, from Australia, but this species is adorned with well-marked somewhat distantly spaced spiral striæ.

Clathurella epentroma, n. sp. Figs. 3, 4.

Shell small, narrowly fusiform, the spire slender. Colour light reddish-brown or dull-chestnut. Whorls 5½, rounded or obscurely angled above the periphery, adorned with fine spiral and longitudinal sculpture, the latter strongest. Sutures deep. Protoconch of about one and a half whorls, strongly angled, and with four smooth narrow revolving riblets, the posterior minute and situate near to the suture; the apical half-turn obliquely curved down and somewhat imbedded in the succeeding whorl. The last whorl rather longer than the spire. Adult sculpture: The longitudinals number fifteen to sixteen small riblets on the last whorl, equal to or rather wider than the interspaces, and usually less developed on the anterior end; they are continuous in some, irregular in others. The spirals consist of undulating delicate riblets and threads. On the spire-whorls there are two, and on the last seven or eight slightly stronger; of these the four posterior are more widely spaced, two are above the outer lip and one in line with it; frequently forming beads on crossing the longitudinals. Within these spaces there are, on that adjoining the suture, four or five threadlets, sometime irregular in size; on the succeeding three spaces, usually three threadlets in each, the median one frequently strongest. Anterior to this the interspaces with one to three threads. The old beaks sometimes forming short irregular riblets. Aperture of medium breadth, less than half its length. Outer lip simple, the posterior sinus shallow. Columella lightly curved, the anterior canal short and broad. Length, 5·73 mm.; breadth, 2·11 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

This is a very beautifully sculptured little shell. The spirals on the anterior portion of the last whorl are somewhat variable in number and strength. The lightly angular appearance of the spire whorls in some individuals is due to the more prominent spirals being rather more pronounced; the spaces on these whorls are similarly adorned to the posterior portion of the last.

Clathurella epentroma, Murdoch, var. **whangaroaensis**, n. var. Fig. 5.

Differs from the typical form in the whorls being strongly angled, spire somewhat turrited, and the principal spiral riblets much more pronounced, but similarly placed. Colour, number of whorls, and protoconch the same as typical. Longitudinal ribs fourteen on the last whorl, equal to or narrower than the interspaces. Spirals—on the spire whorls two, and on the last four or five, prominent and forming beads on crossing the longi-

tudinals. In addition there are on the anterior end a few more crowded and rather smaller. The interspaces with spiral striæ, four or more, usually minute, sometimes almost microscopic. Outer lip with usually five well-marked sinuations corresponding to the principal spirals, posterior sinus shallow. Length, 6·83 mm.; breadth, 2·5 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

This form appears to somewhat approach *Mangilia connectans*, Sowb.,* from South Australia.

Mitromorpha suteri, n. sp. Fig. 6.

Shell small, fusiform, somewhat thin, with fine spiral and usually somewhat obsolete longitudinal riblets. Colour light reddish-brown, sometimes a pale band around the periphery, occasionally a narrow darker band at the sutures. Whorls 5, lightly rounded, the last longer than the spire. Protoconch of two whorls, somewhat globose, smooth and polished, the apical turn oblique to the succeeding whorl. Sculpture: The penultimate whorl with six to seven and the last with sixteen to twenty spiral riblets, seven or eight of which are in front of the aperture; they are slightly variable in strength, some in breadth equal to the interspaces, others rather narrower; also an occasional small thread here and there arises in the interspaces. Longitudinals irregular, low and rounded, more distinct on the spire, frequently obsolete. The growth striæ irregular, somewhat marked, and frequently cutting up the spirals into minute gemmules. Sutures impressed, usually margined with a wider riblet. Aperture somewhat narrow, rather longer than the spire. Outer lip thin, a little flattened; the posterior sinus broad, well marked. Columella almost straight, concave and lightly callused; the canal short and broad. Length, 4·56 mm.; breadth, 1·70 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

At first glance this species might easily pass for a *Columbella*. From *M. substriata*, Suter, it is at once distinguished by its colour and much stronger spiral sculpture. It appears to be nearest to *M. subabnormis*,† Suter, the latter characterized by the well-developed oblique longitudinal riblets. Suter described this species as *Clathurella*, but it would appear to be more in harmony with *Mitromorpha*.

I have much pleasure in associating with this species the name of Mr. Henry Suter, of Auckland.

* Proc. Mal. Soc. London, vol. ii., p. 30, pl. iii., fig. 14.

† Trans. N.Z. Inst., vol. xxxi., p. 74, pl. iii., figs. 5, 5*a*.

Drillia lyallensis, n. sp. Fig. 7.

Shell small, fusiform, rather solid. Colour light or dark brownish-red, or somewhat purple (slightly beach-worn specimens). Whorls 6–6½, rather flattened, spire with a lightly turrited appearance, apex smooth ; last whorl much longer than the spire, with eleven or twelve low, strong, rounded and slightly oblique ribs, rather wider than the interspaces, obsolete on the anterior half and usually on approaching the outer lip. Spiral sculpture consists of minute striæ, erased upon the ribs, a few at the anterior end stronger, and frequently several rough irregular ridges the remains of the old beaks. Sutures impressed, somewhat deep. Aperture narrow. Outer lip slightly thickened, the posterior sinus near to the suture and moderately deep. Columella lightly curved, not heavily callused ; the canal short, broad, and slightly twisted. Length, 12 mm. ; breadth, 4·56 mm.

Type in the Colonial Museum.

Hab. Lyall Bay (Mr. C. Freyberg).

This species is not uncommon in shell sand, but in the majority of specimens the finer sculpture is totally erased. Most examples show prominent scars, flexures repaired during the life of the animal. Of the five specimens before me, three are pierced by a carnivorous mollusc, and, strange as it may appear, each in exactly the same spot—a little above and to the left of the outer lip. In sculpture the species most resembles *Clathurella sinclairi*, Smith.

Cerithiopsis sarissa, n. sp. Figs. 8, 9.

Shell small, narrow, and tapering to a slender point, adorned with spiral and slightly weaker longitudinal riblets which form gemmules on the lines of intersection, base smooth. Colour light or dark brown, somewhat shining ; the sutures of the anterior whorls, fourth spiral on the last, and base dark-purplish. Whorls 11–12, sutures deep. Apical whorls without sculpture ; the succeeding with three spiral and numerous slightly oblique longitudinal riblets forming rows of gemmules. On the anterior whorls the sutures are margined with a minute beaded riblet ; this gradually strengthens, and on the last whorl forms a fourth spiral, with the beading less marked than on the rows immediately above ; beneath this a shallow groove, thence gently curved to the columella, and curving obliquely around the latter is a minute ridge which terminates at the canal. Of the three spiral rows of gemmules the two anterior are the largest, and about equal to the interspaces. The gemmules, of which on the last whorl there are seventeen to twenty per row, are somewhat oval, shining and variously coloured, light-brown, pale-chestnut,

and purple. Aperture ovate, with a well-marked chestnut band on the base, and the colour of the sculpture feebly produced. Outer lip sharp, sinuous. Columella short, nearly straight, and the beak slightly twisted to the left. Length, 6·25 mm.; breadth, 1·8 mm.

Type in the Colonial Museum.

Hab. Kawhia Harbour, immediately within the entrance, on rocks at low tide (R. M.); Whangaroa Harbour and Plimmerton, Cook Strait (Mr. Hamilton).

This beautiful little shell appears to be quite distinct from other New Zealand species. The few specimens obtained are, except that from Kawhia, dead and somewhat bleached; nevertheless the only example with the apex uninjured is from Whangaroa. The protoconch consist of about 3½ smooth rounded whorls, the apex globose, with the first half-turn oblique. The brephic period is not very distinctly marked off—it appears to consist of one volution; upon it a spiral riblet commences, which on the succeeding whorls forms the anterior spiral; thence follows somewhat strong longitudinal striæ, marking as it were short periods of growth, and from amidst these arise two posterior spirals, abruptly followed by the adult sculpture.

Leptothyra fluctuata, Hutton. Fig. 10.

Cyclostrema fluctuata, Hutton, Trans. N.Z. Inst., vol. xvi., p. 215 (1883, issued May, 1884). *Leptothyra fluctuata*, Hutton, Pilsbry, Man. Conch. (1), vol. x., p. 259, pl. 64, figs. 47, 48. *L. fluctuata*, Hutton, "Index Faunæ Novæ-Zealandiæ," p. 81.

This species occurs in fair numbers. The irregular waved longitudinal bands of brown are well marked in some individuals; they extend across the base, but do not reach the umbilicus; the latter usually whitish, at times with broad white radiations. The spiral cingula vary from about twenty-five to thirty-five on the last whorl; the umbilicial area frequently cut up with strong irregular growth-periods. The outer lip descending, rather sharply in some, a thick callus uniting it to the columella. Height, 2·42 mm.; breadth, 3·11 mm.

The figure is derived from specimens collected by Mr. A. Hamilton at Whangaroa Harbour.

Captain Hutton kindly compared these northern forms with the types in the Canterbury Museum.

Hab. Foveaux Strait.

I have also to record the species from the Pliocene formation, Shakespeare Cliff, Wanganui—a single example, smaller than the recent forms.

Leptothyra crassicostata, n. sp. Fig. 11.

Shell small, solid, turbinate, with strong variable spiral sculpture. Colour whitish or light brown, occasionally with irregular markings of brown, most distinct on and below the periphery. Whorls 4, spire short, apex minute and without sculpture. The penultimate whorl with three to five, and the last with twelve to twenty, spiral ribs, four to nine of which are in front of the aperture. The ribs are very variable in size; there are five to eight strong riblets between the periphery and suture on the outer lip; in front of the aperture four or five about equal to the breadth of the interspaces. On and immediately below the periphery frequently small and crowded, similar on the base, or there may be two or three more prominent intercalated with the smaller spirals, or the basal riblets generally stronger than those on the periphery. The growth-lines strong and irregular, producing here and there a lightly costate appearance, frequently pronounced in the umbilical area. Sutures impressed. Aperture subrotund. Outer lip sharp, descending, rather sharply in some. Columella lightly curved, somewhat produced and expanded anteriorly, a thick posterior callus spreading across to the outer lip. Umbilicus small and deep. Operculum circular, somewhat calcareous, of six or seven narrow folds, the nucleus central. Height, 2·49 mm.; breadth, 3·21 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

Distinguished from *L. fluctuata*, Hutton, by its much stronger sculpture.

Columbella huttoni, Suter, nom. mut. Fig. 12.

Lachesis sulcata, Hutton, Cat. Marine Moll. N.Z., p. 12 (1873); Cat. Tertiary Moll. and Echin. N.Z., p. 5; Manual N.Z. Moll., p. 45. *Columbella huttoni*, Suter, for *sulcata*, Hutton, preoccupied, "Index Faunæ Novæ-Zealandiæ," p. 72 (1904).

The specimen figured is from the material collected by Mr. A. Hamilton at Whangaroa Harbour. The shell is small, robust, with well-marked spiral riblets somewhat wider than the grooves: last whorl longer than the spire, lightly carinate, more distinct in front of the aperture. Colour ash-grey, brown, or reddish-brown, sometimes variegated with white. Whorls rather flattened, 6 in number, including a 2- or 2½-whorled smooth reddish-brown protoconch. Sculpture: On the penultimate whorl five and on the last twelve to fourteen spiral riblets, five of which are in front of the aperture; a few of the riblets on the anterior end are minute, sometimes absent. These are crossed by irregular growth-lines, which give to the shell a slightly roughish appearance. Sutures impressed. Aperture oval, outer lip simple;

columella curved, lightly callused, and frequently a small denticle at the anterior end. Length, 6 mm.; breadth, 2·52 mm.

The type locality is Stewart Island, the types preserved in the Canterbury Museum. They would appear to be somewhat larger than the northern forms.

Columbella transitans, n. sp. Fig. 13.

Shell small, fusiform, somewhat shining, with well-marked spiral grooves usually less than half the breadth of the interspaces. Colour light or dark brown, olive, or reddish-brown; some examples with a lighter band immediately below the sutures and produced around the periphery, in others this band is darker than the ground-colour. Whorls 6, rather flattened, the last longer than the spire. Protoconch of two and a half whorls, smooth and shining, light or dark olive, the apex usually lightest. Sutures impressed. Sculpture: The penultimate whorl with five or six and the last with seventeen to twenty-one spiral grooves, six or seven of which are in front of the aperture; occasionally a wider space surrounds the periphery, lightly cleft with a minute groove; longitudinally striate with irregular growth-periods. Aperture oval. Outer lip simple, uniformly curved. Columella lightly callused, the canal short and broad. Length, 5·11 mm.; breadth, 2·14 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

From *C. huttoni*, Suter, it may be distinguished by its smaller size, more numerous and much narrower spiral grooves. Its sculpture suggests a position intermediate with that species and the next form described.

Columbella paxillus, n. sp. Fig. 14.

Shell small, slender, smooth or with minute spiral grooves; the last whorl lightly angled, only noticeable in front of the aperture. Colour light-brown or reddish-brown or almost black, the sutures occasionally a little lighter. Whorls 5½–6, lightly convex, the last longer than the spire. Protoconch of about two whorls, not well defined, apex polished. Sutures impressed. Sculpture: A few small spirals on the anterior end of the last whorl; above the periphery and on the spire minute, irregular, or absent; occasionally a few inconspicuous longitudinal riblets on the upper whorls of the spire. Aperture short, oval. Outer lip simple. Columella curved and lightly callused, the anterior canal short and broad. Length, 5·04 mm.; breadth, 2·04 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton); Whangarei

Heads; also Takapuna, Manukau, Kawhia, and New Plymouth.

This little shell occurs in fair numbers. It is nearest to the preceding species; distinguished by the minute irregular spiral grooves, or their frequent absence except on the anterior end.

I may mention that *Pyrene flexuosa*, Hutton (dark form), is quite different in contour from the above: it has the form of *C. choava*, Reeve, and is probably only a colour variety of that extremely variable species.

Columbella saxatilis, n. sp. Fig. 15.

Shell small, ovate-elongate, sculptured with fine spiral and stronger longitudinal riblets. Colour light or dark brown, usually a pale band around the periphery. Whorls 6, rather flattened. Protoconch of two whorls, smooth and polished. Last whorl comparatively large. Sutures impressed. Sculpture: Longitudinal ribs sixteen to eighteen on a whorl, low and rounded, equal to or a little less than the breadth of the interspaces, becoming obsolete on the anterior end and usually on approaching the outer lip. Spirals undulating, small but well marked, wider than the grooves; on the penultimate six or seven, and on the last sixteen to seventeen, about seven of which are in front of the aperture; on crossing the longitudinals they have occasionally a somewhat granular appearance. Aperture somewhat narrow, longer than the spire. Outer lip rather flattened, a little thickened, and occasionally a few obscure denticles thereon. Columella frequently with two or three small folds or tubercles, the beak lightly twisted to the left; canal short and broad. Length, 5·86 mm.; breadth, 2·73 mm.

Type in the Colonial Museum.

Hab. Takapuna, from sand in rock-pockets (R. M.); Plimmerton, Cook Strait.

This species is perhaps nearest to *C. pisaniopsis*,* Hutton, a Pliocene form.

Crossea glabella, n. sp. Figs. 16, 17.

Shell minute, turbinate, smooth and rather solid. Colour white, somewhat shining. Whorls 3, without sculpture. Spire minute. Sutures distinct, not deep, with a narrow slightly concave depression below and adjoining. Base with broad depression, bounded by a prominent ridge; a second ridge arises from the narrow deep umbilicus; both sweep round to the anterior lip, where they form small well-marked expansions. Aperture subcircular. Inner lip reflected and callused, the latter

* Trans. N.Z. Inst., vol. xvii., p. 314; Macleay Mem. Vol., p. 45, pl. vi., fig. 17.

spreading across to the outer lip, which is sharp and simple. Height, 1·97 mm.; breadth, 1·94 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton). Found also at Stewart Island (A. H.).

This species, in its smoothness, solidity, and scanty umbilicus, is perhaps nearest to *C. carinata*,* Hedley, from New South Wales (75–100 fathoms). It appears to be the first record of the genus from New Zealand.

Odostomia impolita, Hutton. Fig. 18.

Rissoa impolita, Hutton, Cat. Marine Moll. N.Z., p. 29 (1873); Proc. Lin. Soc. N.S.W., vol. ix., p. 941. *Barleeia impolita*, Hutton, Manual N.Z. Moll., p. 81. *B. impolita*, Hutton, Suter, Proc. Mal. Soc. London, vol. iii., p. 7. *Odontostoma impolita*, Hutton "Index Faunæ Novæ-Zealandiæ," p. 74.

The figure offered is derived from specimens in the collection of Mr. Henry Suter (*hab.* Foveaux Strait). These specimens have 5 whorls (one more than given in the description of the species), including the minute polished apex, the heterostrophe character of which is not very clear, due apparently to its being much buried in the succeeding whorl. The whorls are convex, the last much longer than the spire. Spiral striæ minute, rather more pronounced on the anterior half of the last whorl. Columella plait small, the lip anteriorly slightly effuse.

The types are in the Colonial Museum.

Hab. Stewart Island.

Odostomia proxima, n. sp. Fig. 19

Shell small, elongated, rather fragile, smooth. White and slightly shining. Whorls 6, somewhat rounded, the last a little longer than the spire; the apical whorl minute, polished and heterostrophe. Sutures deeply impressed, not channelled. Sculptured with longitudinal irregular minute growth-periods, in places slightly pronounced, usually more marked on the spire. These are crossed by minute spiral striæ and scratches, very irregularly spaced, in some almost absent except for a few on the anterior half of the last whorl. Aperture small, ovate, oblique; columella slightly thickened and reflected, the plait not prominent; the lip anteriorly rather effuse. Base narrowly perforate. Length, 3·9 mm.; breadth, 1·8 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

Distinguished from *O. impolita*, Hutton, by its more rounded

* "Memoirs Australian Museum," vol. iv., pt. 6 (Thetis), 1903, p. 345, fig. 71.

whorls and greater number, deeper sutures, irregular sculpture, and comparatively longer spire. It appears to be equally distinct from *O. fasciata*,* Hutton, a Pliocene form.

Odostomia vestalis, n. sp. Fig. 20.

Shell small, slender, fragile, smooth, and having a somewhat loosely coiled appearance. White and shining. Whorls 6, lightly convex; the last longer than the spire; apical whorl heterostrophe, slightly obliquely tilted. Sutures impressed, shallow and lightly submargined. Sculptured with minute irregular growth-lines, crossed by irregular microscopic striæ, the latter only indicated here and there. Aperture pyriform; columella lightly reflected, the plait small, rather deep within the aperture; anterior lip lightly effuse. Length, 4·31 mm.; breadth, 1·63 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

This form, of which there is but a single example, is nearest to the preceding species; distinguished by its more slender form, more shallow sutures, less rounded whorls, and more rapidly lengthening or loosely coiled appearance.

Odostomia (Pyrgulina) rugata, Hutton.

Odostomia (*Parthenia*) *plicata*, Hutton (not of Montford), Trans. N.Z. Inst., vol. xvii., p. 319, pl. xviii., fig. 17 (1884, issued May 1885). *Odostomia rugata*, Hutton (nom. mut.), Trans. N.Z. Inst., vol. xviii., p. 353 (1885, issued May 1886); "Macleay Memorial Volume," p. 58, pl. vii., fig. 51.

This species has hitherto been recorded only as a Tertiary fossil. Pliocene: Wanganui and Petane. Found also in the Pareora system. It appears to be rare, both fossil and recent. Of the latter I have seen but three examples, and not in very good condition. I may add—the shell is white, somewhat shining and rather solid; the longitudinal riblets strong, slightly oblique advancing, seventeen to eighteen on the last whorl, feeble or obsolete on the anterior end; spirally adorned with minute dense striæ. Sutures impressed and lightly margined. Columella plait strong. Measurements (approx.): Length, 2·76 mm.; breadth, 1·28 mm. The fig. 51 in the "Macleay Memorial Volume" shows the riblets on the spire-whorls sloping forward, or advancing in a most marked manner. In the examples before me the slope is certainly less than half that shown in this figure.

Hab. Whangaroa Harbour, and Plimmerton, Cook Strait (Mr. A. Hamilton); Takapuna (Rev. W. H. Webster).

* Trans. N.Z. Inst., vol. xvii., p. 320; Macleay Mem. Vol., p. 58, pl. vii., fig. 50.

Vulpecula (Pusia) hedleyi, n. sp. Fig. 21.

Shell small, shortly fusiform, sculpture minute. Colour greyish-white, occasionally very faintly mottled with brown. Whorls 4½–5, rather flattened; spire short, conical, apex blunt; the last proportionally very large. Sutures lightly impressed. Sculptured with minute spiral grooves and with irregular longitudinal plications, the latter slightly more prominent at the sutures. Aperture oblique, narrow and much longer than the spire. Lip uniformly curved and slightly thickened. Columella white, lightly callused and armed with four plaits, the anterior two more oblique; opposite the latter the columella is lightly swollen. Anterior canal short and broad. Length, 5·42 mm.; breadth, 2·63 mm.

Type in the Colonial Museum.

Hab. Whangarei Heads, dredged in shallow water (Mr. C. Cooper, of Auckland).

Distinguished from other New Zealand species by the feeble longitudinal sculpture and short spire. I have much pleasure in naming this species after Mr. Charles Hedley, of the Australian Museum—a token of appreciation of his invariable kindly assistance.

Trophon (Kalydon) curta, n. sp. Fig. 22.

Shell small, ovate, rather solid, spirally and longitudinally ribbed, the latter strongest and forming prominent nodules on the lines of intersection. Colour whitish, occasionally a brown band on the base, rarely a few ill-defined scattered spots on the periphery. Whorls 6, lightly shouldered. Protoconch of two whorls, smooth except the last half-turn, upon which two small spirals arise. The sculpture consists of ten or eleven, rarely twelve, longitudinal ribs, narrower than the interspaces except when the latter number occurs, then equal or rather wider. Of the spirals there are two on the spire-whorls and six or seven on the last—occasionally three on the penultimate and eight on the last; the anterior spiral not infrequently prominent and the nodules sometimes obsolete. Aperture ovate. Outer lip slightly expanded, the margin occasionally feebly dentate; anterior canal short and somewhat curved. Length, 5·7 mm.; breadth, 2·59 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

Occurs in fair numbers, and appears to be the smallest of the genus recorded from New Zealand.

Rissoa leptalea, n. sp. Figs. 23, 24.

Shell minute, subrimate, slender, smooth, and rather fragile. Colour white, shining and semi-transparent. Whorls 5, having a somewhat loosely coiled, and those of the spire swollen, ap-

pearance. Apex minute; the last whorl longer than the spire. Without sculpture except the microscopic growth-lines. Sutures impressed and lightly margined. Aperture ovato-subcircular, peristome continuous; the columella and lip broadly expanded, the latter shortly descending. Length, 1·94 mm.; breadth, 66 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

Of this minute form there are only two examples. It is perhaps nearest to *R. lubrica*,* Suter, from Stewart Island.

Rissoa microstriata, n. sp. Fig. 25.

Shell minute, ovate-elongate, smooth and white. Whorls 5, somewhat swollen at the shoulders, thence gently flattened to the sutures; the latter impressed and lightly margined. Apex minute; last whorl longer than the spire. The sculpture consists of microscopic dense spiral striæ, broken up into variable lengths by the irregular lines of growth. Aperture obliquely broadly ovate; lip slightly thickened, a callus spreading across the body to the columella; the latter thickened and lightly reflected. Length, 2·11 mm.; breadth, 1·08 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

This little shell is perhaps near to *Barleeia neozelanica*,† Suter, while the sculpture, though microscopic, may be compared with *Rissoa emarginata*, Hutton, a Pliocene form.

Rissoa insculpta, n. sp. Fig. 28.

Shell small, elongate, slightly rimate, rather fragile. White. Whorls 5, lightly rounded; the last whorl much longer than the spire; the apex minute. Sutures impressed. Sculptured with minute spiral threadlets, absent on the apical whorls, about sixteen on the penultimate, and on the last about twenty-five, of which seventeen to eighteen are in front of the aperture. These are crossed by irregular growth-lines, here and there rather pronounced. Aperture broadly ovate, slightly oblique, and the peristome continuous. Columella regularly curved, lightly thickened and expanded, anteriorly a little produced; outer lip slightly thickened and projecting from the whorl above. Length, 2·56 mm.; breadth, 1·35 mm.

Type in the Colonial Museum.

Hab. Whangaroa Harbour (Mr. A. Hamilton).

This form is near to *R. foveauxiana*,‡ Suter. It differs in

* Proc. Mal. Soc. London, vol. iii., p. 5, fig. iii. (in text).

† Proc. Mal. Soc. London, vol. iii., p. 8, fig. v. (in text, on p. 5).

‡ Proc. Mal. Soc. London, vol. iii., p. 5, fig. ii. (in text).

being more slender, more feebly rimate, sculpture much finer, sutures less deep, and the whorls less rounded. Perhaps the preceding species, *R. microstriata*, is next in the order of kinship. For comparison I herewith offer a figure of *R. foveauxiana*, derived from specimens identified by Mr. H. Suter; also a figure of *R. fumata*, Suter, derived from a typical specimen (*hab.* Lyall Bay).

List of Species from Whangaroa Harbour.

Class **Gasteropoda.**

Marinula filholi, *Hutton.*
Leuconopsis obsoleta, *Hutton.*
Cylichna striata, *Hutton.*
Drillia lævis, *Hutton.*
Surcula zealandica, *E. A. Smith* = cheesemani, *Hutton* (*not* novæ-zealandiæ, *Reeve*).
Mitromorpha substriata, *Suter.*
„ subabnormis, *Suter.*
„ suteri, *Murdoch.*
Mangilia flexicostata, *Suter.*
Clathurella sinclairi, *E. A. Smith.*
„ epentroma, *Murdoch.*
„ „ *var.* whangaroaensis, *Murdoch.*
Daphnella lacunosa, *Hutton.*
Cancellaria trailli, *Hutton.*
Trophon duodecimus, *Gray.*
„ plebejus, *Hutton.*
„ curta, *Murdoch.*
„ pumila, *Suter* = ambiguus Philippi *var.* pumila, *Suter* = T. bonneti, *Cossmann.*
Columbella choava, *Reeve.*
„ huttoni, *Suter.*
„ transitans, *Murdoch.*
„ paxillus, *Murdoch.*
Taron dubius, *Hutton.*
Vulpecula rubiginosa, *Hutton.*
Leiostraca murdochi, *Hedley.*
Odostomia angasi, *Tryon.*
„ proxima, *Murdoch.*
„ vestalis, *Murdoch.*
Pyrgulina rugata, *Hutton.*
Turbonilla zealandica, *Hutton.*
Cæcum digitulum, *Hedley.*
Turritella carlottæ, *Watson.*
„ kanieriensis, *Harris.*
Cerithiopsis terebelloides, *von Martens.*
„ sarissa, *Murdoch.*

Potamopyrgus antipodum, *Gray.*
Rissoa huttoni, *Suter.*
„ hamiltoni, *Suter.*
„ subfusca, *Hutton.*
„ „ *var.* micronema, *Suter.*
„ foveauxiana, *Suter.*
„ cheilostoma, *Ten.-Woods.*
„ suteri, *Hedley.*
„ rosea, *Hutton.*
„ neozelanica, *Suter* (Barleeia).
„ leptalea, *Murdoch.*
„ microstriata, *Murdoch.*
„ insculpta, *Murdoch.*
Rissoina rugulosa, *Hutton.*
Eatoniella olivacea, *Hutton.*
Littorina mauritiana, *Lamarck.*
Risellopsis varia, *Hutton.*
„ „ *var.* carinata, *Kesteven.*
Calyptræa maculata, *Quoy and Gaimard.*
„ scutum, *Lesson.*
Trichotropis inornata, *Hutton.*
Crossea glabella, *Murdoch.*
Natica australis, *Hutton.*
Scala zelebori, *Frauenfeld.*
Janthina exigua, *Lamarck.*
Leptothyra fluctuata, *Hutton.*
„ crassicostata, *Murdoch.*
Phasianella limbata, *Hutton.*
Trochus tiaratus, *Quoy and Gaimard.*
Cantharidus dilatatus, *Sowerby.*
„ sanguineus, *Gray.*
Monilea egena, *Gould.*
Calliostoma punctulatum, *Martyn.*
Ethalia zelandica, *Hombron and Jacquinot.*
Incisura lytteltonensis, *E. A. Smith* (Scissurella).
Megatebennus moniliferus, *Hutton.*
Emarginula striatula, *Quoy and Gaimard.*
Acmæa pileopsis, *Quoy and Gaimard.*

Class Pelecypoda.

Barnea similis, *Gray.*
Saxicava arctica, *Lin.*
Cardium pulchellum, *Gray.*
Chione crassa, *Quoy and Gaimard.*
Tapes fabagella, *Deshayes.*
Cyamiomactra problematica, *Bernard.*
Kellya sanguineum, *Hutton.*

Kellya parva, *Deshayes.*
Lasea miliaris, *Philippi.*
Diplodonta zelandica, *Gray.*
Divaricella cumingi, *Adams and Angas.*
Cryptodon flexuosum, *Montague.*
Cuna delta, *Tate and May.*
Verticipronus mytilus, *Hedley.*
Cardita aviculina, *Lamarck.*
Venericardia zealandica, *Potiez and Michaud.*
,, corbis, *Philippi.*
Lima bullata, *Born.*
Pecten zelandiæ, *Gray.*
Philobrya meleagrina, *Bernard.*
,, costata, *Bernard.*
Barbatia decussata, *Sowerby.*
Glycymeris striatularis, *Lamarck.*
Nucula nitidula, *A. Adams.*
Leda concinna, *A. Adams.*
Malletia australis, *Quoy and Gaimard.*

Class **Brachiopoda.**

Terebratella rubicunda, *Sowerby.*
Rhynchonella nigricans, *Sowerby.*

EXPLANATION OF PLATES VII. AND VIII.

Plate VII.

Figs. 1, 2. *Cylichna striata*, Hutton.
Figs. 3, 4. *Clathurella epentroma*, n. sp.
Fig. 5. *Clathurella epentroma*, var. *whangaroaensis*, n. var.
Fig. 6. *Mitromorpha suteri*, n. sp.
Fig. 7. *Drillia lyallensis*, n. sp.
Figs. 8, 9. *Cerithiopsis sarissa*, n. sp.
Fig. 10. *Leptothyra fluctuata*, Hutton.
Fig. 11. *Leptothyra crassicostata*, n. sp.
Fig. 12. *Columbella huttoni*, Suter.
Fig. 13. *Columbella transitans*, n. sp.
Fig. 14. *Columbella paxillus*, n. sp.

Plate VIII.

Fig. 15. *Columbella saxatilis*, n. sp.
Figs. 16, 17. *Crossea glabella*, n. sp.
Fig. 18. *Odostomia impolita*, Hutton.
Fig. 19. *Odostomia proxima*, n. sp.
Fig. 20. *Odostomia vestalis*, n. sp.
Fig. 21. *Vulpecula hedleyi*, n. sp.
Fig. 22. *Trophon curta*, n. sp.
Figs. 23, 24. *Rissoa leptalea*, n. sp.
Fig. 25. *Rissoa microstriata*, n. sp.
Fig. 26. *Rissoa fumata*, Suter.
Fig. 27. *Rissoa foveauxiana*, Suter.
Fig. 28. *Rissoa insculpta*, n. sp.

ART. XIII.—*Report on the Mollusca collected by Messrs. Keith Lucas and G. L. Hodgkin in Six Lakes of New Zealand.*

By HENRY SUTER.

[*Read before the Wellington Philosophical Society, 7th September, 1904.*]

DURING the year 1902 Messrs. Keith Lucas and G. L. Hodgkin, of Cambridge, made a collection of the fauna of a typical series of lakes in New Zealand, most of the Mollusca being obtained by dredging. Before reaching New Zealand Mr. Lucas had promised Mr. Charles Hedley, conchologist of the Australian Museum, Sydney, to hand him over the Mollusca which would be obtained from our lakes for study, but later on, with Mr. Hedley's consent, the whole of the material was handed over to me. My very best thanks are due to Messrs. Lucas and Hodgkin for allowing me to study the interesting collection, and to my friend Mr. Hedley for his most readily given consent.

Mr. Lucas has published in the Geographical Journal for May and June, 1904, a highly interesting and beautifully illustrated report on the "Bathymetrical Survey of the Lakes of New Zealand," and Professor W. B. Benham, of Dunedin, has published* the result of his study of the aquatic *Oligochæta* collected by Messrs. Keith Lucas and Hodgkin.

The lakes from which Mollusca were handed over to me are the following: North Island—Waikare, Rotoiti, Taupo, Waikaremoana; South Island—Wakatipu, Manapouri.

With regard to the deep-water Mollusca of our lakes nothing at all was known, all the collecting hitherto done having been confined to shallow water, and mostly, of course, near the shore. To show how scanty our knowledge of the molluscan fauna of the above-named lakes has been, it may be of interest to mention that the following species have been recorded: Lake Rotoiti —*Sphærium novæ-zelandiæ*, Desh. (as *lenticula*, Dk.), *Potamopyrgus badia*, Gould (as *fischeri*, Dk.), both collected by Hochstetter, and *Melanopsis trifasciata*, Gray. Lake Taupo—*Diplodon menziesi*, Gray (Dieffenbach), and its subsp. *hochstetteri*, Dk. (Hochstetter). Lake Waikaremoana—*Diplodon menziesi*, Gray (as *waikarense*, Colenso). Lake Wakatipu — *Planorbis corinna*, Gray, and *Isidora antipodea*, Sow., both collected by Captain F. W. Hutton.

I propose to describe first, in systematical order, all the molluscs brought together, then to give a synopsis of the molluscan fauna of each lake, and finally tabulate the bathymetrical distribution of the species.

* P.Z.S., 1903, vol. ii., pp. 202-232, pls. xxiv.-xxvi.

Fam. UNIONIDÆ.

Genus DIPLODON, Spix (1827).

Shell elliptical, rounded, elongated or trapezoidal, with rather low beaks which are more or less distinctly radially sculptured, the ridges usually curved and approaching below, with a low or scarcely developed posterior ridge; surface slightly concentrically sculptured, sometimes broken into fine nodules or corrugations; epidermis dull, rayless; hinge with two compressed pseudocardinals in the right valve, and one slender lateral, and two compressed pseudocardinals in the left valve, one in front of the other, and two laterals; nacre bluish to white, dull, often blotched; beak-cavities shallow; dorsal scars numerous, forming a row in the beak-cavity parallel with the hinge line.

Animal with the marsupium occupying nearly the whole length of the inner branchiæ, a few ovules sometimes being found in the outer gills; branchiæ rather large, angular at base, inner much the larger, united their whole length to the abdominal sac; palpi scarcely projecting posteriorly; mantle very thin, thickened on the edges; branchial opening papillose, separated from the smooth anal opening by a strong bridge; supra-anal opening not closed below. (Simpson.)

Type: *D. ellipticum*, Spix.

Subgenus HYRIDELLA, Swainson (1840).

Beaks rather low, sculpture consisting of curved generally nodulous ridges, which approach below, but usually have a smooth area of shell between them; surface sulcate or sometimes corrugated and nodulous; epidermis rayless; teeth rather delicate, compressed, often somewhat rudimentary.

Animal having the embryos occupying the inner gills for the most part, which are united for their entire length to the abdominal sac; outer gills pointed below in the middle; palpi triangular; branchial opening papillose; anal opening smooth, not separated from the supra-anal opening. (Simpson.)

Type: *Unio australis*, Lamarck.

Diplodon menziesi, Gray (1843).

Unio menziesi, Gray, in Dieffenbach's "New Zealand," vol. ii., 1843, p. 257. *Unio aucklandica*, Gray, *l.c.*, p. 257. *Unio waikarense*, Colenso, Tasman. Journ. Nat. Sci., vol. ii., 1845, p. 250.

I am following C. Simpson in considering *Unio aucklandica* as a synonym only. On examining a rather large series of specimens from over twenty localities I tried to uphold it at least as

a subspecies, but I had to give it up, as I had numerous specimens before me which could be either assigned to *menziesi* or to *aucklandica*. There is no doubt that when the extreme forms only are compared one would feel inclined to take them for distinct species, but so it is with many other species, as for instance with *Helcioniscus tramosericus*. However, it is convenient to refer to *aucklandica* as a form of *menziesi* which is but little winged, and having the dorsal and ventral margins subparallel.

Unio waikarense will be dealt with further on when describing the mussels from Lake Waikaremoana.

(1.) *Lake Taupo* (Stat. 9—From dredgings up to 100 ft.).—There are eight specimens, representing quite young to half-grown forms, only one being highly winged. All are distinctly radiately striate, and some of the youngest specimens show the typical beak-sculpture beautifully. It is represented by the accompanying diagram (fig. 1). One of the larger specimens is very distinctly sculptured with elongate nodules on the lower half down to the ventral margin in the region below the beaks. The interior and hinge are the same as in specimens of subspecies *hochstetteri*, to be described further on. The largest specimen measures—Length, 42 mm.; height, 28 mm.; diam., 13 mm.

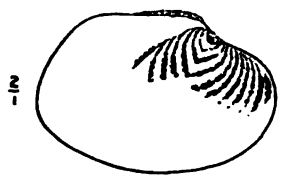


Fig. 1

(2.) *Lake Taupo* (Stat. 9F—From dredgings up to 100 ft.).—The eight specimens have the same appearance as those of the last station; all of them have the outline of *aucklandica*, are finely radiately striate, and one clean olive-coloured specimen also shows nodulous ornamentation. Five quite young specimens have the beaks already so much eroded that no trace of the beak-sculpture is left. A few specimens have a light ferrugineous coating. The largest specimen shows—Length, 43 mm.; height, 28 mm.; diam., 13 mm.

(3.) *Lake Waikaremoana* (Stat. 14—Dredged in 50 ft.).—Compared with the type of *Unio waikarense*, Colenso, said to have been obtained in this lake, the four specimens collected at this station are much smaller, very little winged posteriorly, the dorsal margin subparallel to the ventral, darker in colour, and more solid; they are not concentrically sulcated, but only striated, and the marks of rest are much less distinct. All of them are finely radiately striated, a character always to be found in *menziesi*. The pseudocardinals are typical, the upper lateral tooth in the left valve is much lower than the other, and crenate

in all specimens. Inside bluish-white, pearly, blotched with yellowish, especially in the umbonal cavity.

(4.) *Lake Waikaremoana* (Stat. 37 — Dredged in 15 ft.).— Four specimens of different size, showing all the characters of those from Stat. 14.

In some specimens in my collection, kindly sent to me by Mr. Elsdon Best, and collected in Lake Waikaremoana, the radiate sculpture is distinctly nodulous, sometimes V-shaped, thus approaching *D. websteri*, Simpson. Typical specimens of *aucklandica* from creeks near Auckland show the same sculpture to a most marked degree, and I consider *D. websteri* as a *D. menziesi* in which the nodulous sculpture is developed to the highest degree.

I have seen, thanks to Mr. E. Best's great kindness, a large number of *Diplodon* from Lake Waikaremoana, but not one approaching Colenso's type of *waikarense*, which is a large, thin, yellowish-olive-coloured shell, having more the appearance of an *Anodonta*. The Waikaremoana specimens are all much smaller, thicker, darker in colour, and less winged. Mr. A. Hamilton, Director of the Colonial Museum, to whom I spoke about it, and who has visited the locality, suggests that Colenso did not get his specimens from Lake Waikaremoana itself, but from some small lake or lagoon in the vicinity. This seems to be correct, as I obtained, again through the unremitting kindness of Mr. E. Best, a number of specimens from a lagoon near Ruatoki, Tuhoe-land, and these are typical *waikarense*, Colenso; one of them showing the same outline and the same dimensions as the cotype in the Canterbury Museum.

An error in Colenso's diagnosis of *Unio waikarense* (Trans. N.Z. Inst., xiv., 169) wants correcting. He says, "Posterior slope keeled." This, however, is not correct: the shell is *not keeled*. How misleading such an incorrect statement is may be guessed from Simpson's remark on the species in his "Synopsis of the Naiades," p. 890 (footnote): "Suter thinks this is a variety of *menziesi*, but Colenso states that the posterior slope is keeled. If this is so it must be quite different from the species." There is also an error in the quotation in Simpson's work, as he gives the year 1841 as the date of the publication of the Tasman. Journ. Nat. Sci. vol. ii., whereas it is 1845. Colenso says that he discovered the shell in 1841, but his description was published four years later.

I have compared typical specimens of *waikarense* with many specimens of *menziesi* from about twenty different localities, and I am unable to separate the two. In all essential characters the two agree, and there remains nothing but to make Colenso's species a synonym of *D. menziesi*, Gray.

Diplodon menziesi, Gray, subsp. hochstetteri, Dunker (1862).

Unio hochstetteri, Dunker, Malak. Blätter, vol. viii., 1862, p. 153.

The type was collected by Hochstetter in the Waikato River.

(1.) *Lake Taupo* (Stat. 46—From dredgings in 10–30 ft.).—Six specimens, blackish-brown, much corroded round the beaks, most of them more produced and rounded posteriorly than the type, but some have the posterior end distinctly truncated and more or less biangular. In correspondence with Mr. C. T. Simpson I expressed the opinion that *hochstetteri* is a pathological subspecies,* having seen the same form amongst specimens of *rugatus*, Hutton, from the Kopuaranga River,† and also amongst *menziesi* from the River Avon. The young shells are invariably typical *D. menziesi*, but on growing larger the deformity constituting *hochstetteri* becomes more and more apparent. Some specimens are more affected, others less, thus producing a strongly truncated biangular posterior margin, or it remains only flatly rounded. At the posterior end the periostracum is produced in thick, foliated layers, and the inner margin is considerably thickened by pearly substance, forming large rugosities, and very often pearls adhering to the shell are met with. Loose small pearls of irregular form are only exceptionally found. In my opinion the cause of this is most likely some parasitic creature, as is the case in most of the pearl-producing bivalves. The outer exposed layers round the beaks are smooth, light-brown, waxy. The concentric striation is rather coarse, the marks of rest distinct and elevated. The inside is but little iridescent, except along the ventral margin, outside the mantle impression, grey to light-brown, sometimes blotched with brown; there are more or less considerable rugosities beyond those at the posterior margin. The dorsal scars in the umbonal cavity are small and deep, and to the number of two to four. The anterior adductor impressions are irregular in shape, and much deeper than the posterior ones, which are oval and shallow. Right valve with two pseudocardinals, the upper anterior forming a small lamella, the posterior being strong, compressed, high, triangular, and slightly corrugated. The single lateral tooth is regularly slightly curved and somewhat crenate at its posterior end, which is abruptly descending. Left valve with two pseudocardinals arising from a common base, both blunt, the anterior tooth larger and but slightly crenate. The two laterals are also curved, the lower of them is strongly lamellated and denticulated at its posterior end, which slopes down very gradually.

* C. T. Simpson, "Synopsis of the Naiades," p. 889 (footnote).
† Trans. N.Z. Inst., xxiv., 275.

(2.) *Lake Rotoiti* (Stat. 8—Obtained by dredging in 12 ft.).—Two specimens of medium size, strongly concentrically ridged, umbones much eroded, posterior end subtruncated, not yet distinctly biangular. They represent the intermediate stage between the young *menziesi* and the full-grown *hochstetteri*. Interior olive-bluish, pearly, a row of small dorsal scars in the umbonal cavity, parallel to the hinge line. Muscular scars strongly impressed. Right valve with two very unequal pseudocardinals, the anterior small, lamellar, the posterior compressed, with a broad posterior base, crenulated, trifid; the lateral tooth slightly curved, narrow, high, truncate and corrugate posteriorly. Left valve with the two pseudocardinals coalescent, separated only by a groove, the anterior strong, triangular, rugose. The two laterals with crenate edges, obliquely truncated behind. The dimensions of the two specimens are—Length, 50 mm.; height, 34 mm.; diam., 16 mm.: and, length, 41 mm.; height, 29 mm.; diam., 12·5 mm.

Diplodon menziesi, Gray, subsp. rugata, Hutton (1883).

Unio rugatus, Hutton, N.Z. Journ. Sci., vol. i., 1883, p. 478.

Lake Waikare (Stat. 41—From dredgings in all parts of the lake; most common on sand and on stony shore).—Six specimens, two of which are quite young. The latter are winged posteriorly. the beaks already eroded, and there are three to six nodulous ridges descending in front of the umbo, nearly parallel to the anterior margin; they are concentrically finely thread-striated; colour olive-brown; the inside is bluish-pearly, yellow under the beaks. The larger specimens are subventricose and thin, less winged, the dorsal margin nearly parallel to the length-axis; the beaks are corroded, the anterior margin rounded, sometimes slightly truncate, the posterior margin produced and the ventral margin broadly convex. The concentric striae are irregular, rugose posteriorly, fine and more regular at the anterior end; the marks of rest are fairly distinct. Most of the specimens are partly covered with a dark-brown ferrugineous coating. Interior bluish, yellowish, or purple pearly, sometimes strongly blotched with olive. Muscular scars shallow. Right valve with two compressed triangular pseudocardinals close together, the anterior tooth smaller, lamellar and smooth, the posterior stronger, broader, and somewhat rugose. The lateral tooth is slender, curved, rugose on the edge of the posterior part. Left valve with two elongated, rounded, rugose pseudocardinals which sometimes coalesce, when only a slight notch indicates the original two teeth. The two laterals are long, slender, sinuate, and distinctly pectinate at the posterior edges. There are always a few small rather deep dorsal scars in the umbonal cavity.

Diplodon menziesi, Gray, n. subsp. lucasi.

Lake Manapouri (Stat. 35—Dredging in 60 ft.).—Three specimens; one of them may be taken as adult. Shell (figs. 2 and 3) oblong-ovate, very much compressed, thin and fragile, inequilateral, beaks low, eroded; surface with close strongly pronounced rest-marks and between them a few lines of growth, all close together and foliated at the anterior end. In the adult specimen the middle part has distinct radiate nodulous sculpture, partly V-shaped, but no such ornamentation is to be found on the young specimens. The straight dorsal margin is subparallel to the ventral margin, which is slightly sinuate; the anterior margin is angularly rounded, the posterior obliquely truncated and slightly produced. Nearly the whole of the shell is covered with a thin ferrugineous coating; the epidemis is olive-green, waxy. The ligament is small, not much raised. In the right valve the two pseudocardinals are compressed, small; the upper anterior tooth is a small, smooth lamella, the lower tooth is more elevated, conoidal, and strongly crenate; the lateral tooth is almost straight, thin and rugose at its posterior portion. In the left valve there is a rather long compressed lower anterior rugose pseudocardinal, the upper tooth is quite rudimentary; the upper lateral tooth is a little higher and more rugose posteriorly than the other. Interior bluish-white, pearly, a little blotched with olive in the umbonal cavity, where there are rather large and deep dorsal scars. The adductor-muscle scars are shallow. The young specimens are slightly winged.

Fig. 3

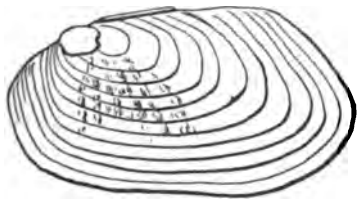


Fig. 2

This subspecies is nearest to the typical *aucklandica*, but is distinguished from it by its exceptionally compressed form, the thinness of the shell, the strongly marked and close concentric lines, the more tapering posterior margin, and the feebly developed pseudocardinals. The radiate nodulous sculpture is found in many specimens of *menziesi* and its subspecies. Adult specimen —Length, 45 mm.; height, 24 mm.; diam., 8 mm.

Type in my collection.

I have much pleasure in naming the subspecies in honour of its discoverer, Mr. Keith Lucas.

Diplodon lessoni, Küster (1856).

Unio lessoni, Küster, Conch. Cat., 1856, p. 135, pl. xxxvi., fig. 4. Type from New South Wales.

Lake Wakatipu (Stat. 37—Dredged in 10 ft. to 30 ft.).—Nine specimens were obtained. Shell (fig. 4) oblong, obliquely truncated behind, compressed, inequilateral, beaks strongly eroded in all specimens, no trace of sculpture left; surface with distant flatly elevated rest-marks, which, together with the intervening space, are covered with very fine thread-like concentric lines; towards the base and posterior margin the growth-lines are more distinct and slightly foliated. There is no trace of radial sculpture. The epidermis is olive to dark-brown, dull. Interior bluish nacre, with yellowish patches under the beaks, where there are several deep small dorsal scars. Right valve: The pseudocardinals are compressed, the anterior upper tooth is small, grooved, the posterior tooth much larger and crenate; the lateral tooth is slightly arched and rugose posteriorly. Left valve: Anterior pseudocardinal compressed, tongue-shaped, slightly rugose, the posterior subtriangular, deeply denticulate; the laterals are of nearly equal height and crenate posteriorly.

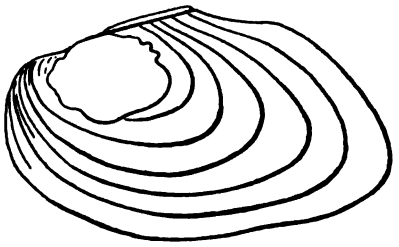


Fig 4.

The largest specimen was selected for the diagram and description, and its dimensions are—Length, 51 mm.; height, 30 mm.; diam., 14½ mm.

I submitted specimens to Dr. W. H. Dall, Hon. Curator of Mollusks, U.S. Nat. Museum, for examination, and he very kindly informed me that according to the material in the museum they are *D. lessoni*, Küster. I have not seen any Australian specimens, nor the description and figure published by Küster, but I do not hesitate to accept Dr. Dall's view, although some may think it hazardous to refer our shell to a New South Wales species. I have not seen this species from anywhere else in New Zealand.

Dr. Von Jhering once suggested that a number of measurements should be taken to ascertain the range of variability in species of the family *Unionidæ*. I have measured a great number of specimens from New Zealand some years ago, and may publish the results later on. I have done the same for a number of the *Unionidæ* collected by Messrs. Lucas and Hodgkin, and

the result is contained in the following table. [The ciphers i. to xi. in the table indicate—i. Length of shell. ii. Greatest height. iii. Index of height (length = 100, height in % of it). iv. Distance of greatest height from anterior end. v. Index of position of greatest height (length = 100, distance of greatest height in % of it). vi. Diameter. vii. Index of diameter (length = 100, diameter in % of it). viii. Length of hinge line. ix. Distance of beak from anterior end of hinge line. x. Umbonal index (length of hinge line = 100, distance of beak from anterior end of hinge line in % of it). xi. Cardinal index (length of shell = 100, length of hinge line in % of it).]

——	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.
D. menziesi.											
Taupo, 9 ..	32	19	59	..	..	9	28	..	..	..	..
,, 9F ..	37	23	62	..	..	10	27	..	..	..	..
Waikaremoana, 14	44	28	64	23	52	13	29	32	9	28	72
,, 14	41	23	56	25	61	10	24	25	6	24	61
,, 14	39	22	56	21	53	10	27	24	6	25	61
Mean of the three above	41	24	58	23	55	11	27	27	7	25	64
Waikaremoana, 37	55	32	58	30	54	18	32	38	10	26	69
,, 37	60	33	55	28	47	17	28	40	10	25	67
,, 37	61	36	59	31	50	19	31	40	10	25	66
,, 37	62	33	53	31	50	19	30	40	10	25	64
Mean of the four above	59	33	56	30	50	18	30	39	10	25	64
Cotype of *waikarense*	79	48	61	40	51	25	31	47	10	21	59
D. hochstetteri.											
Taupo, 46 ..	48	31	65	24	50	16	33	36	8½	24	75
,, 46 ..	52	36	70	30	58	18	35	35	8	23	67
,, 46 ..	54	36	67	30	56	19	35	40	10	25	74
,, 46 ..	64	40	63	33	52	22	34	48	11	23	75
Mean of the four above	55	38	66	29	54	19	34	40	9½	24	72
From Lake Rotorua, typical	61	44	72	32	52	24	39	42	10	24	69
D. rugata.											
Waikare, 41 ..	47	28	59	22	47	14	29	31	8	26	66
,, 41 ..	46	29	63	26	56	15	32	30	8	26	65
,, 41 ..	44	26	59	20	45	13	29	25	6½	26	57
,, 41 ..	41	25	61	21	51	13	31	29	8	27	70
Mean of the four above	44	27	60	22	50	14	30	29	8	26	64
From Lake Pearson, cotype	52	33	63	26	50	17	32	35	9	25	67
D. lucasi.											
Manapouri, 35 ..	45	24	53	19	42	8	18	28	8	28	62
,, 35 ..	34	21	61	16	47	8	23	22	7	31	64
,, 35 ..	28	17½	62	15	53	6½	23	18	5	28	64
D. lessoni.											
Wakatipu, 37 ..	51	30	58	23	45	14½	28	35	9	26	68
,, 37 ..	44	24	58	22	53	11½	28	26	7½	28	63

Fam. SPHÆRIIDÆ.

Cardinal teeth not exceeding two in each valve, and exhibiting a cessation of development at an early stage. (Dall.)

The New Zealand species of *Sphærium* and *Corneocyclas* are not easily separated with regard to their generic position, as both are about to the same extent inequilateral, though in *Corneocyclas* the anterior part is mostly more attenuated and the nepionic shell sometimes more conspicuous than in *Sphærium*. The cardinal teeth are very variable, and it is a tedious job to ascertain the genus from these alone, but they assist in the general diagnosis. To be absolutely certain living specimens should be examined, *Sphærium* having two siphonal tubes, *Corneocyclas* only one; but with the specimens to be described that was out of the question. Fortunately I have specimens of both genera from New Zealand in my collection, which I examined when alive, and these were of great help to me for the study of the various specimens collected by Messrs. Lucas and Hodgkin.

Much useful information was obtained from the chapter on the family *Sphæriidæ* in the classical work of Dr. W. H. Dall, "Tertiary Fauna of Florida."

The indices I calculated for the *Sphæriidæ* are part of those used for the *Unionidæ*: iii. = index of height; vii. = index of diameter; x. = umbonal index.

Genus SPHÆRIUM, Scopoli (1777).

Subgenus SPHÆRIUM, Scopoli, s.s.

Type: *S. corneum*, Linné.

The nepionic shell passing into the adult without any distinct demarcation; the anterior end shorter; the ligament subinternal; the two right cardinals widely divergent and coalescent at their adjacent or upper ends, thus apparently forming but one tooth, but which if it had continued in development would have separated into two; the widening of the ventral angle causes the Λ-shape to disappear; the nepionic shell (and consequently the beaks) is finely concentrically striate or even nearly smooth and rather convex. (Dall.)

Sphærium novæ-zelandiæ, Deshayes (1853).

Cat. Conchif. Brit. Museum, p. 272; P.Z.S., 1854, p. 342.

(1.) *Lake Rotoiti* (Stat. 15—From muddy bottom and weeds in 6 ft.).—Three specimens of nearly equal size, suborbicular, subequilateral; colour grey, near the ventral margin yellowish; beaks covered with a ferrugineous incrustation. Nepionic shell

hardly to be distinguished from the later growth, obtuse; anterior side of shell slightly produced, rounded, posterior side broadly convex; the whole of the valves concentrically finely striate. Ligament inset. Left valve with a straight lamellar upper cardinal, and below and slightly in front of it a curved stouter tooth. In the right valve the two cardinals are united, forming an oblong squarish tooth with three denticulations on the lower margin. Laterals smooth. Fig. 5 illustrates the cardinal teeth of the two valves. Length, 5 mm.; height, 4¼ mm.; diam., 2⅔ mm. Umbo 3 mm. from anterior end. The indices are—iii. = 85; vii. = 55; x. = 60.

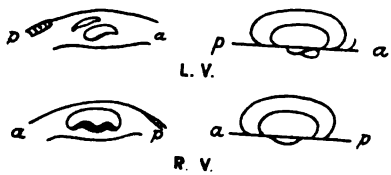


Fig. 5

This is no doubt the same as *S. lenticula*, Dunker, as Hochstetter obtained the specimens from the lakes Rotoiti and Taupo, and I consider it as a synonym of *S. novæ-zelandiæ*.

(2.) *Lake Taupo* (Stat. 4—Dredged with weeds in 20 ft., and from bottom of coarse pumice in 100 ft.).—Four specimens of straw colour, the nepionic shell rather distinct, but otherwise not differing from the typical form. Right valve with two minute cardinals, the anterior oblong, the posterior short, triangularly oval, elevated. Left valve with two minute teeth, broadly rounded behind, pointed at the anterior end, one in front of the other. Fig. 6 shows the form and position of the cardinals. Length, 4½ mm.; height, 4 mm.; diam., 2½ mm. Umbo 2¾ mm. from anterior end. Indices—iii. = 84–89; vii. = 56; x. = 61.

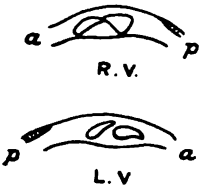


Fig. 6

(3.) *Lake Taupo* (Stat. 34—With weeds from 20 ft. to 80 ft.).—Six small specimens, a little more oval and compressed, but otherwise the same as the examples from Stat. 4. Length, 4 mm.; height, 3 mm.; diam., 1¾ mm. These are the dimensions of Dunker's *S. lenticula*. Indices—iii. = 75; vii. = 44.

(4.) *Lake Waikaremoana* (Stat. 33—Dredged in 10 ft. to 20 ft.).—There are twenty-three small to minute specimens. The larger examples are yellowish-grey, the small ones straw-colour. In the right valve there are two lamellar cardinal teeth meeting at an obtuse angle; in the left valve there is one crescent-shaped

rounded cardinal, and a strong bifid crenulated cardinal below and slightly in front of it. Fig. 7 illustrates the cardinals of the two valves. The lateral teeth are smooth; the ligament inset. Dimensions of two specimens — Length, 4¼ mm.; height, 3½ mm.; diam., 2 mm.; beak 2½ mm. from anterior margin: length, 4 mm.; height, 3½ mm.; diam., 2 mm.; beak 2¼ mm. from anterior margin. The mean of the indices is—iii. = 85; vii. = 49; x. = 58.

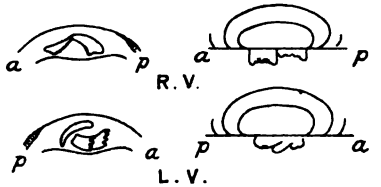


Fig. 7.

Genus CORNEOCYCLAS, Férussac (1818).

(= *Pisidium*, Pfeiffer, &c.)

Subgenus CORNEOCYCLAS.

Nepionic shell convex, concentrically striated; hinge with two separate cardinals in the left, and a single compound, usually arcuate, cardinal in the right valve. (Dall.)

Sec. *Corneocyclas*, s.s.

Type: *Tellina pusilla*, Gmelin.

Nepionic valves passing into the mature disc without any strong demarcation; the anterior cardinal and lateral adjacent and retaining traces of their original connection; ligament internal. (Dall.)

Corneocyclas novozeelandica, Prime (1862).

P.Z.S., 1862, p. 3.

(1.) *Lake Waikare* (Stat. 29—From weeds in 1½ ft. to 2 ft.).—Nine specimens of different size; colour greyish-yellow, shining, inequilateral, with fine concentric lines, which are crossed by close microscopic radiate striæ. Nepionic shell convex, concentrically striated, well delimited, but passing without any change into the disc of the adult valve. Ligament inset. Right valve with the two cardinals remaining united, crescent-shaped; four laterals. Left valve with two cardinals, the posterior bifid, the anterior triangular; two laterals. The accompanying fig. 8 shows the characters of the hinge.

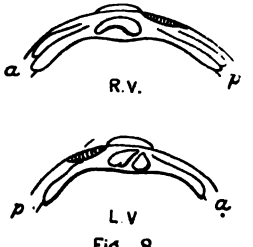


Fig. 8

Four specimens were measured — Length, 2¾–5 mm.; height, 2½–4 mm.; diam., 1¼–2½ mm.: and the mean indices are—iii. = 83; vii. = 48; x. = 59.

These specimens are very much like those I collected in the River Avon, Christchurch.

(2.) *Lake Waikare* (Stat. 29F—From weeds in 1½ ft. to 2 ft.).—Four specimens, dead when collected. They do not differ much from those of Stat. 29, except being slightly more globular. The dimensions of three specimens measured are — Length, 5 mm.; height, 4½ mm.; diam., 3¼ mm.; umbo 3 mm. from anterior margin: length, 4¼ mm.; height, 3½ mm.; diam., 2¼ mm.; umbo 2½ mm. from anterior margin: length, 3 mm.; height, 2½ mm.; diam., 1½ mm.; umbo 1¾ mm. from anterior margin. The mean indices are—iii. = 85; vii. = 56; x. = 58.

(3.) *Lake Wakatipu* (Stat. 17—Dredged with weeds in 20 ft. to 100 ft.).—One minute specimen, rounded, yellowish-white, subequilateral. Length, 2¼ mm.; height, 2 mm.

This small specimen has the aspect of a *Sphœrium*, but the nepionic shell is so distinct that I prefer placing it in *Corneocyclas* for the present. I tried to separate the valves, but could not do it without running the risk of breaking the valves. Without ample material, and especially examining the living animal, it is impossible to be quite certain about its generic position.

(4.) *Lake Wakatipu* (Stat. 34—Dredged in 10 ft. to 30 ft.).—One adult and four young specimens. The adult is light-brown, the nepionic shell distinctly limited; the young examples are grey to yellowish, more inequilateral and tapering in front. The dimensions of two specimens are—Length, 5¼ mm.; height, 4½ mm.; diam., 2½ mm.; umbo 2¾ mm. from anterior end: length, 3½ mm.; height, 1¾ mm.; diam., 1½ mm.; umbo 2 mm. from anterior end: and the mean indices are—iii. = 83; vii. = 46; x. = 55.

There is one specimen, covered with a black coating, which is suborbicular, much compressed, inequilateral, with inconspicuous beaks, the anterior side broadly rounded. The dimensions are—Length, 4 mm.; height, 3¼ mm.; diam., 1½ mm.; umbo 2½ mm. from anterior end: and the indices are—iii. = 81; vii. = 38; x. = 62. I have seen similar abnormities amongst specimens I collected in the River Avon.

(5.) *Lake Manapouri* (Stat. 13—Dredged in shallow water near the shore).—Three young specimens, which are at once recognised as being *Corneocyclas*, being more inequilateral, compressed and attenuated anteriorly than adult specimens. Had I not seen the same forms from other localities, collected together with adult examples, I might have been inclined to consider

them a distinct species. With few exceptions the young shells of *C. novozeelandica* show the characters just indicated. The colour is light-grey, and the nepionic shell is distinct. The dimensions of two specimens are — Length, 3¼ mm.; height, 2¾ mm.; diam., 1½ mm.; umbo 2 mm. from anterior end: length, 2¾ mm.; height, 2 mm.; diam., 1 mm.; umbo, 2 mm. from anterior end. The mean indices are—iii. = 78; vii. = 41; x. = 66.

Corneocyclas hodgkini, n. sp. Fig. 9.

(1.) *Lake Waikaremoana* (Stat. 18—Dredged in 800 ft.).—Two specimens. They are very small, oval, much compressed, the anterior side produced and attenuated; posterior and ventral margins regularly rounded; colour yellowish-white; beaks obtuse, unconspicuous; nepionic shell distinct, very finely concentrically striated, passing without change into the adult valves, which are irregularly finely concentrically striate. Posterior part with a ferrugineous coating. The dimensions are —Length, 2¾ mm.; height, 2 mm.; diam., 1 mm.; and the indices —iii. = 72; vii. = 36: length, 2 mm.; height, 1¾ mm.; diam., ¾ mm.; and the indices—iii. = 87; vii. = 50.

Fig. 9

Named in honour of Mr. G. L. Hodgkin, who so ably assisted Mr. Lucas in his arduous work.

Type in my collection.

(2.) *Lake Taupo* (Stat. 10—Dredged in 280 ft. and 320 ft., muddy bottom).—Six small specimens, thickly coated all over with ferrugineous earth, so that the form of the shell is unrecognisable. I succeeded in cleaning one specimen, and found it to agree with the specimens just described from Lake Waikaremoana. Dimensions of the cleaned specimen—Length, 3 mm.; height, 2½ mm.; diam., 1 mm.

Fam. HYDROBIIDÆ.

Genus POTAMOPYRGUS, Stimpson (1865).

Americ. Journ. Conch., vol. i., 1865, p. 53.

Potamopyrgus corolla, Gould (1847).

Melania corolla, Gould, Proc. Bost. Soc. Nat. Hist., vol. ii., 1847, p. 223.

(1.) *Lake Waikare* (Stat. 19—From reeds).—One specimen, with black coating and six rounded whorls. Length, 5½ mm.; breadth, 3¾ mm.

(2.) *Lake Taupo* (Stat. 16 and 16F—Dredged in 280 ft. and 320 ft., muddy bottom).—Four specimens, all of which are

shouldered and with traces of stout setæ; covered with a dark-brown coating; there are seven whorls, the peritreme is continuous. The dimensions range from 7 × 4½ mm. to 6½ × 4½ mm.

Potamopyrgus corolla, Gould, subsp. salleana, Fischer (1860).

Paludestrina salleana, P. Fischer, Journ. de Conch., vol. viii., 1860, p. 208, pl. iv., fig. 6.

(1.) *Lake Waikare* (Stat. 14 and 14F—Among reeds).—From Stat. 14 are thirteen adult and a number of young shells; from Stat. 14F twelve specimens, exactly the same as the former. Most of them are of horn-colour, with a white calcareous coating; three only are coated with black. All, with the exception of one, are spinous, the spines being distant, rather short, bent upward. In some specimens a distinct angle below the periphery is present. All the adult shells are smaller than the type, with six whorls. The dimensions range from 4½ × 2½ mm. to 5¼ × 3¼ mm.

(2.) *Lake Rotoiti* (Stat. 18—Dredged with weeds in 6 ft.).—Seventeen specimens of rather uniform size and shape, covered with a greenish-black coating. There are five rounded smooth whorls; only one specimen shows traces of bristles on the upper whorls. The peritreme is sometimes, not always, black. A few specimens are approaching *corolla*, being more ventricose than the subspecies. The dimensions vary from 5 × 3 mm. to 6 × 4 mm.

(3.) *Lake Rotoiti* (Stat. 18F—Dredged with weeds in 6 ft.).—Sixteen specimens, all "dead shells." Very much the same as the preceding. Dimensions range from 5 × 3 mm. to 5½ × 3¼ mm.

(4.) *Lake Taupo* (Stat. 6—Dredged in 25 ft. to 420 ft.).—Many specimens, all light-horn colour, about two-thirds with smooth rounded whorls, the others with a carina above the periphery on which very short spines are situated, having a broad base, from which two to three separate spines arise. This is a feature met with in specimens of *P. corolla* from Lake Kanieri, South Island. The variability of the arrangement of the spines is just as great as in *P. badia*. The pullus is mostly brown and shining. The first two and a half whorls are always convex, never shouldered. The peritreme is continuous and brown. Young specimens have sometimes the body-whorl angled below the periphery, but no chordate carina is present. The size is very variable, ranging from 5 × 3 mm. with six whorls to 8½ × 5 mm. with seven whorls.

(5.) *Lake Taupo* (Stat. 6F—Dredged in 25 ft. to 420 ft.).—About two dozen specimens, showing the same characters as those of Stat. 6. The dimensions vary from 5½ × 3 mm. to 8½ × 5 mm., with six and seven whorls respectively.

(6.) *Lake Taupo* (Stat. 16F—Dredged in 280 ft. and 320 ft.,

muddy bottom).—All the seven specimens are "dead shells," therefore very fragile. They are shouldered, with traces of spines, covered with a dark-brown coating; no carina below the periphery. Dimensions range from 6½ × 4 mm. to 8½ × 5 mm.

(7.) *Lake Taupo* (Stat. 39—With weeds, from 20 ft. to 80 ft.). —There are seventeen specimens, of light-horn colour, and of an astonishing variability. Some call to mind the graceful, slender *P. egenus*, while others are more ventricose and short. Especially the elongated specimens show a very distinct angle on the body-whorl, arising from the junction of the outer lip with the whorl. Only a few are shouldered, but devoid of spines. The peritreme is dark-brown. The dimensions of four specimens are—4 × 2¾ mm.; 5½ × 2½ mm.; 6 × 3 mm.; 6 × 3½ mm. All adult specimens have six whorls.

(8.) *Lake Taupo* (Stat. 39F—With weeds, from 20 ft. to 80 ft.). —Four small specimens, covered with a grey coating, with six smooth convex whorls and a brown peritreme. They come very near *P. antipodum*, subsp. *zelandiæ*, but the whorls are more convex and the suture deeper. This is the most extreme form of *salleana* I have seen. The dimensions are—4 × 2¼ mm.; 4¼ × 2¼ mm.; 4½ × 2¼ mm.; 5 × 2½ mm.: the ratio of breadth to length varying from 1 : 1·6 to 1 : 2.

(9.) *Lake Taupo* (Stat. 40—With weeds, from 20 ft. to 80 ft.).— A large number of young specimens, most of which are distinctly angled below the periphery. Only two adult specimens, one smooth, one with spines. Colour, &c., the same as in examples from Stat. 39. The dimensions are 5 × 2½ mm. and 5 × 3 mm., with six whorls.

(10.) *Lake Taupo* (Stat. 40F—With weeds, from 20 ft. to 80 ft.).—Numerous young specimens, none adult, showing the same characters as those from Stat. 40, but they are covered by a green coating.

(11.) *Lake Taupo* (Stat. 47—Dredged in 400 ft.).—Four adult specimens, with a very thick black coating, very markedly shouldered, seven whorls, no spines, but there is an exceptionally strong carina; mouth snow-white. Dimensions, 7 × 4¼ mm.

(12.) *Lake Waikaremoana* (Stat. 3—Dredging in 50 ft. to 100 ft.).—Fifteen adult specimens, of a cinereous colour, with six whorls which are mostly shouldered and have rudimentary bristles; a few only have rounded smooth whorls. Peritreme light-brown. Dimensions range from 4½ × 2½ mm. to 6 × 3½ mm. These may be considered as typical forms.

(13.) *Lake Waikaremoana* (Stat. 17—Dredging in 800 ft.).— One specimen, a "dead shell," with the last whorl broken off. It is thickly coated with calcareous substance, stained orange by oxide of iron. There are rudimentary spines visible on one

whorl. Currents very likely brought this specimen to this considerable depth.

(14.) *Lake Waikaremoana* (Stat. 34—Dredging in 10 ft. to 20 ft.).—There are thirty-four adult shells, cinereous to black according to the amount of coating covering the shell. Most of them have six rounded smooth whorls, a few only are shouldered, none have spines. Peritreme brown. The dimensions vary from 5 × 2¾ mm. to 6½ × 3¾ mm. These also are typical examples.

(15.) *Lake Manapouri* (Stat. 15—From shallow water near the shore).—Two large adult specimens, both of which are of horn-colour, broadly shouldered, with distant brown spines on the carina, two or three arising from a common broad base. The larger example shows distinctly the slightly chordate carina below the row of spines on the last whorl, a character mentioned by P. Fischer. The other species, however, shows no trace of it; and it is, as I have pointed out elsewhere, not a constant but an extremely rare feature of *salleana*. The dimensions of the two shells are—8 × 5 mm. and 7 × 4 mm.

I have similar specimens from Lake Kanieri, kindly collected for me by Dr. Macandrew, of Hokitika, but they are more ventricose, and I assign them to *P. corolla*.

Potamopyrgus badia, Gould (1848).

Amnicola badia, Gould, Proc. Bost. Soc. Nat. Hist., vol. iii., 1848, p. 75.

(1.) *Lake Wakatipu* (Stat. 10—Dredged with weeds in 200 ft. to 300 ft.).—Seven shells of very light horn-colour, rather variable in size and shape. Only one, the largest, has spines; the others have the whorls convex, a few showing indications of a keel. They are very thin and fragile, the peritreme continuous in all, and light-brown. The largest shell measures 7 × 3½ mm., and it is very similar to the large specimens found in Lake Te Anau. The smallest shell, with six whorls, is 5 × 2¾ mm.

(2.) *Lake Wakatipu* (Stat. 18—Dredged with weeds in 20 ft. to 100 ft.).—Ten shells, three of which are not adult, very variable in size, of light-horn colour, and very thin. Four have smooth, rounded whorls, two are slightly shouldered, and four are spinous. On the lower whorls the setæ are far apart, sometimes two to four bristles arising from a common base. All have six whorls, and the dimensions range from 5½ × 2½ mm., 6 × 3¼ mm., to 6¼ × 3½ mm.

(3.) *Lake Wakatipu* (Stat. 6—From weeds fringing shore).—Seven shells of horn-colour, covered with a thin white coating, six convex whorls, suture impressed. Some examples are slightly shouldered on the upper whorls, with minute close-set short bristles. All are of about the same size—4¼ × 2¼ mm.

Fam. L I M N Æ I D Æ.

Sub-fam. ANCYLINÆ.

Genus GUNDLACHIA, Pfeiffer (1849).

Zeitschrift f. Malak., vol. vi., 1849, p. 98.

Gundlachia lucasi, n. sp. Figs. 10, 11.

Lake Waikare (Stat. 30 and 30F—Netting in weeds).—Three specimens; two of them were collected alive. Shell obliquely conical, thin, semitransparent, horn-colour, covered by a blackish coating; apex inclined to the right, situated at the posterior third of the length; convex anteriorly, slightly concave on the posterior slope; a few concentric lines of growth. Aperture oval; peritreme sharp, extremely fragile. No septum, the shells being in the *Ancylus* stage of development only. Dimensions of two specimens—Length, 3 mm.; breadth, 2 mm.; height, 1 mm.: length, 4 mm.; breadth, 2½ mm.; height, 1½ mm. The dentition is very similar to that of the *Gundlachia* sp. from the River Avon,* which settles the generic position.

Fig. 10

Fig. 10a

This species stands nearest to *G. tasmanica*, T.-Woods. It is more rounded and elevated than the species from the River Avon. There is also one specimen of *G. lucasi* from Inglewood in my collection.

The occurrence of two species of *Gundlachia* in three different localities leaves no doubt that the genus is endemic, and accidental introduction out of the question.

Type in my collection.

I have great pleasure in uniting with the species the name of Mr. K. Lucas, who so ably and successfully collected the fauna of New Zealand lakes.

Sub-fam. LATIINÆ.

Genus LATIA, Gray (1850).

Latia neritoides, Gray (1850).

P.Z.S., 1849, p. 168 (1850).

Lake Waikare (Stat. 35—Dredged in 4 ft.; stony shore).—One small typical specimen, 5 mm. long.

Sub-fam. LIMNÆINÆ.

Genus AMPHIPEPLEA, Nilsson (1822).

Nilsson, Hist. Moll. Suec., p. 58.

Amphipeplea arguta, Hutton (1885).

Trans. N.Z. Inst., vol. xvii., p. 54, pl. xii., fig. 1.

(1.) *Lake Waikare* (Stat. 19 and 19F—From reeds).—Fourteen

* Trans. N.Z. Inst., xxvi., pl. xiv., fig. 5.

mostly young shells. Colour horny, columellar lip broadly reflexed. Dimensions—Shell: length, 7 mm.; breadth, 4 mm. Aperture: height, 5 mm.; breadth, 4 mm. Shell: length, 5½ mm.; breadth, 4 mm. Aperture: height, 4½ mm.; breadth, 3 mm.

(2.) *Lake Taupo* (Stat. 42—With weeds from 20 ft. to 80 ft.).—One specimen collected alive; yellowish-white, rather slender. The aperture more elongated than in the type. Shell: length, 5½ mm.; breadth, 3½ mm. Aperture: height, 4 mm.; breadth, 2½ mm.

(3.) *Lake Wakatipu* (Stat. 10—Dredged with weeds in 200 ft. to 300 ft.).—One specimen collected alive; nearly colourless, transparent, very thin and fragile, with broad columellar reflection; regular distinct incremental lines. The aperture is longer and narrower than in the type. Shell: length, 5¼ mm.; breadth, 3¼ mm. Aperture: height, 4½ mm.; breadth, 2½ mm.

(4.) *Lake Wakatipu* (Stat. 33—Dredged in 30 ft. to 60 ft.).—Two specimens collected alive. A slender form with elongated aperture, of horn-colour, with regular lines of growth, and the spire a little higher than typical. Shell: length, 5 mm.; breadth, 3 mm. Aperture: height, 3½ mm.; breadth, 2¼ mm. Shell: length, 4 mm.; breadth, 2½ mm. Aperture: height, 3½ mm.; breadth, 1⅞ mm.

Fig 11

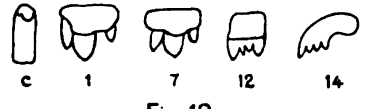


Fig. 12

Fig 13

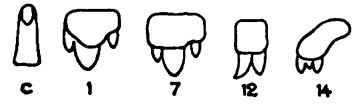


Fig. 14

The Dentition.—Figs. 11–14 represent the most characteristic teeth of the radula of specimens from the four localities—fig. 11 from Lake Waikare, fig. 12 from Lake Taupo, fig. 13 from Stat. 10, and fig. 14 from Stat. 33, Lake Wakatipu. Compared with Hutton's description and figure of his species* a considerable variability, especially in the transitional teeth, is at once apparent. The central tooth shows mostly a second small denticle on the left side; the lateral teeth have all three cutting-points, but the entocone and mesocone may coalesce, forming only one cutting-point, as was evidently the case in the example

* Trans. N.Z. Inst., xvii., p. 54, pl. xii., fig. 10.

figured by Hutton. The number of laterals and marginals is very variable, and the figures sufficiently show the different arrangements of the cutting-points on the transitional teeth.

Sub-fam. PLANORBINÆ.

Genus PLANORBIS (Guett.), Geoffroy (1767).

Planorbis (Gyraulus) corinna, Gray (1850).

P.Z.S., 1849, p. 167 (1850).

Lake Waikare (Stat. 33—Obtained by netting in weeds).—One specimen only was found, which has three whorls and a diameter of 2½ mm.

Genus ISIDORA, Ehrenberg (1831).

Isidora tabulata, Gould, subsp. moesta, H. Adams (1861).

P.Z.S., 1861, p. 144.

(1.) *Lake Waikare* (Stat. 19—From reeds).—One specimen only was obtained. It is of light-horn colour, very thin, covered with a greenish coating; there are four whorls, the last two distinctly shouldered and keeled. Columella excavated in the middle, fold distinct, reflection of columellar lip small; outer lip sharp, regularly arched. It is a little more slender than the type. Shell: length, 7 mm.; breadth, 4 mm. Aperture: height, 5 mm.; breadth, 2½ mm. Ratios: i. = 1 : 1·75; ii. = 1 : 2; iii. = 1 : 1·4. (The ratios are the same as in the revision of *Isidora*.)

(2.) *Lake Waikare* (Stat. 28—From weeds in water from 1½ ft. to 2 ft.).—Two specimens of dark-brown colour, solid and large, keeled, the keel becoming obsolete on approaching the aperture; columella twisted. They differ but little from the type. Shell: length, 17½ mm.; breadth, 11 mm. Aperture: height, 11 mm.; breadth, 6 mm. Shell: length, 14 mm.; breadth, 9½ mm. Aperture: height, 10 mm.; breadth, 5 mm. Ratios: i. = 1 : 1·6; ii. = 1 : 1·8; iii. = 1 : 1·6. i. = 1 : 1·5; ii. = 1 : 2; iii. = 1 : 1·4. The accompanying fig. 15 shows some teeth of the radula, which need no explanation. The dentition of our forms of *Isidora* is so variable that I doubt whether it can be used as a help to separate the species. However, a considerable number of animals of each species has to be examined before this point can be settled definitively.

Fig. 15

(3.) *Lake Waikare* (Stat. 28F—From weeds in water from 1½ ft. to 2 ft.).—Two "dead shells," one young, the other nearly adult. They resemble those from the last station, but are a little more ventricose, and have the spire a little shorter. Shell:

length, 15 mm.; breadth, 10 mm. Aperture: height, 10 mm.; breadth, 5·5 mm. Shell: length, 9 mm.; breadth, 6½ mm. Aperture: height, 6 mm.; breadth, 3½ mm. Ratios: i. = 1 : 1·5; ii. = 1 : 1·8; iii. = 1 : 1·5. i. = 1 : 1·5; ii. = 1 : 1·7; iii. = 1 : 1·5.

Isidora lirata, Tenison-Woods (1879).

P.L.S. N.S.W., vol. iii., 1879, p. 138, pl. xiii., fig. 6.

(1.) *Lake Rotoiti* (Stat. 12—From weeds in 6 ft.).—Six specimens, one only adult. The colour is light-horny, some specimens having a dark coating; the whorls are rounded, but slightly flattened below the suture, the spiral striæ are present but not very distinct. Aperture produced at the base, columella twisted. They are slightly more ventricose than the type. Shell: length, 12 mm.; breadth, 7 mm. Aperture: height, 8½ mm.; breadth, 4 mm. Shell: length, 10 mm.; breadth, 6 mm. Aperture: height, 7 mm.; breadth, 3½ mm. Shell: length, 8½ mm.; breadth, 5½ mm. Aperture: height, 5 mm.; breadth, 3 mm. Ratios: i. = 1 : 1·7; ii. = 1 : 2·1; iii. = 1 : 1·4. i. = 1 : 1·7; ii. = 1 : 2; iii. = 1 : 1·4. i. = 1 : 1·5; ii. = 1 : 1·7; iii. = 1 : 1·7.

(2.) *Lake Taupo* (Stat. 7—Dredged with weeds in 75 ft.).—One specimen of cream colour, fragile; four whorls, shouldered down to the middle of the last whorl, carina with short bristles; shell indistinctly spirally striated; columella twisted, aperture much produced anteriorly. More ventricose than the type. Shell: length, 8 mm.; breadth, 5 mm. Aperture: height, 6 mm.; breadth, 3 mm. Ratios: i. = 1 : 1·6; ii. = 1 : 2; iii. = 1 : 1·3.

(3.) *Lake Taupo* (Stat. 38—With weeds, from 80 ft.).—Many, mostly young specimens. They are of a dirty-white colour with a thin whitish coating. Whorls 4, rounded, sometimes flattened below the suture, beautifully regularly spirally striate. Columella twisted, aperture produced anteriorly. These I consider to be typical forms. Shell: length, 9½ mm.; breadth, 6 mm. Aperture: height, 7 mm.; breadth, 3 mm. Shell: length, 8½ mm.; breadth, 4¼ mm. Aperture: height, 6 mm.; breadth, 3 mm. Shell: length, 7½ mm.; breadth, 4½ mm. Aperture: height, 5 mm.; breadth, 2½ mm. Ratios: i. = 1 : 1·6; ii. = 1 : 2·3; iii. = 1 : 1·4. i. = 1 : 1·8; ii. = 1 : 2; iii. = 1 : 1·4. i. = 1 : 1·7; ii. = 1 : 2; iii. = 1 : 1·6. Fig. 16 shows some teeth of the radula. A remarkable feature are the additional denticles on the outer upper side of the marginal teeth.

Fig. 16

(4.) *Lake Taupo* (Stat. 38F—With weeds, from 80 ft.).—Many, mostly young shells. Very much like the specimens from

Stat. 38, but the spiral striation is not so distinct, and the coating is thicker, of a greenish hue.

(5.) *Lake Waikaremoana* (Stat. 4—Dredging in 50 ft.).—Two "dead shells," one adult with the apex broken off. They are rather large, of cream colour, with four rounded but slightly shouldered whorls; distinctly spirally lirate. Columella twisted, and aperture produced at base. Typical forms, though one much larger. Shell: length, 15½ mm.; breadth, 9 mm. Aperture: height, 10 mm.; breadth, 5 mm. Shell: length, 10½ mm.; breadth, 6 mm. Aperture: height, 7 mm.; breadth, 3 mm. Ratios: i. = 1 : 1·7; ii. = 1 : 2; iii. = 1 : 1·6. i. = 1 : 1·8; ii. = 1 : 2·3; iii. = 1 : 1·5.

(6.) *Lake Waikaremoana* (Stat. 5—Dredging in 50 ft.).—Six specimens, two of them quite young. The colour is light-horny, some shells with a ferrugineous coating. The whorls in some are rounded, in others shouldered and the keel ornamented with short bristles. In young specimens the spiral striation is quite distinct. Columella twisted, and aperture produced anteriorly. These again are typical forms. Dimensions of largest specimen: Shell: length, 13 mm.; breadth, 6¾ mm. Aperture: height, 8 mm.; breadth, 4 mm. Ratios: i. = 1 : 1·9; ii. = 1 : 2; iii. = 1 : 1·6.

(7.) *Lake Waikaremoana* (Stat. 32—Dredging in 10 ft. to 20 ft.).—Four nearly adult and four young specimens. They are dirty-white, the longer examples with a light-brown coating. The four whorls are convex, very little flattened below the suture; spiral striation indistinct. These shells are very nearly typical. Dimensions of largest specimen:—Shell: length, 12 mm.; breadth, 6½ mm. Aperture: height, 8·5 mm.; breadth, 4 mm. Ratios: i. = 1 : 1·8; ii. = 1 : 2·1; iii. = 1 : 1·4.

Synopsis of the Molluscan Fauna of the Six Lakes.

Lake Waikare.

Diplodon menziesi, *Gray*, *subsp.* rugata, *Hutton.*
Corneocyclas novozeelandica, *Prime.*
Potamopyrgus corolla, *Gould.*
" " " *subsp.* salleana, *Fischer.*
Gundlachia lucasi, *Suter.*
Latia neritoides, *Gray.*
Amphipeplea arguta, *Hutton.*
Planorbis corinna, *Gray.*
Isidora tabulata, *Gould*, *subsp.* moesta, *H. Adams.*

Lake Rotoiti.

Diplodon menziesi, *Gray*, *subsp.* hochstetteri, *Dunker.*
Sphærium novæ-zelandiæ, *Deshayes.*

Potamopyrgus corolla, *Gould, subsp.* salleana, *Fischer.*
Isidora lirata, *Tenison-Woods.*

Lake Taupo.

Diplodon menziesi, *Gray.*
Sphærium novæ-zelandiæ, *Deshayes.*
Corneocyclas hodgkini, *Suter.*
Potamopyrgus corolla, *Gould.*
,, ,, ,, *subsp.* salleana, *Fischer.*
Amphipeplea arguta, *Hutton.*
Isidora lirata, *Tenison-Woods.*

Lake Waikaremoana.

Diplodon menziesi, *Gray.*
Sphærium novæ-zelandiæ, *Deshayes.*
Corneocyclas hodgkini, *Suter.*
Potamopyrgus corolla, *Gould, subsp.* salleana, *Fischer.*
Isidora lirata, *Tenison-Woods.*

Lake Wakatipu.

Diplodon lessoni, *Küster.*
Corneocyclas novozeelandica, *Prime.*
Potamopyrgus badia, *Gould.*
Amphipeplea arguta, *Hutton.*

Lake Manapouri.

Diplodon menziesi, *Gray, subsp.* lucasi, *Suter.*
Corneocyclas novozeelandica, *Prime.*
Potamopyrgus corolla, *Gould, subsp.* salleana, *Fischer.*
,, badia, *Gould.*

BATHYMETRICAL DISTRIBUTION OF THE MOLLUSCA.

—	Lake.	Depth in Feet.
Diplodon menziesi, *Gray*	Taupo ..	100
,, ,, ...	Waikaremoana	10–50
,, ,, *subsp.* hochstetteri, *Dunker*	Rotoiti ..	12
,, ,, *subsp.* hochstetteri, *Dunker*	Taupo ..	10–30
,, ,, *subsp.* rugata, *Hutton*	Waikare ..	2
,, ,, *subsp.* lucasi, *Suter*	Manapouri ..	60
Diplodon lessoni, *Küster*	Wakatipu ..	10–30
Sphærium novæ-zelandiæ, *Deshayes* ..	Rotoiti ..	6
,, ,, ..	Taupo ..	20–100
,, ,, ..	Waikaremoana	10–20

BATHYMETRICAL DISTRIBUTION OF THE MOLLUSCA—*ctd.*

—	Lake.	Depth in Feet.
Corneocyclas novo-zeelandica, *Prime* ..	Waikare ..	2
„ „ ..	Wakatipu ..	10–100
„ „ ..	Manapouri ..	Shallow
Corneocyclas hodgkini, *Suter*	Taupo ..	280–320
„ „	Waikaremoana	800
Potamopyrgus corolla, *Gould*	Waikare ..	Shallow
„ „	Taupo ..	280–320
„ „ *subsp.* salleana, *Fischer*	Waikare ..	Shallow
„ „ *subsp.* salleana, *Fischer*	Rotoiti ..	6
„ „ *subsp.* salleana, *Fischer*	Taupo ..	20–420
„ „ *subsp.* salleana, *Fischer*	Waikaremoana	10–100
„ „ *subsp.* salleana, *Fischer* (*dead*)	„	800
„ „ *subsp.* salleana, *Fischer*	Manapouri ..	Shallow
Potamopyrgus badia, *Gould*	Wakatipu ..	20–300
„ „	Manapouri ..	Shallow
Gundlachia lucasi, *Suter*	Waikare ..	„
Latia neritoides, *Gray*	„ ..	4
Amphipeplea arguta, *Hutton*	„ ..	Shallow
„ „	Taupo ..	20–80
„ „	Wakatipu ..	30–300
Planorbis corinna, *Gray*	Waikare ..	Shallow
Isidora tabulata, *Gould*, *subsp.* moesta, *H. Adams*	„ ..	2
Isidora lirata, *Tenison-Woods*	Rotoiti ..	6
„ „	Taupo ..	75–80
„ „	Waikaremoana	10–50

SUMMARY.

The Mollusca collected by Messrs. Lucas and Hodgkin in the six lakes of New Zealand belong to nine genera, and these are represented by twelve species and five subspecies. As new we find one subspecies of *Diplodon menziesi*, one species of *Corneocyclas*, and one species of *Gundlachia*. An interesting addition to our fauna is *Diplodonta lessoni*, Küster.

From Lake Rotoiti no specimens of *Potamopyrgus badia*, Gould, and *Melanopsis trifasciata*, Gray, were obtained, but it is almost certain that *Potamopyrgus corolla*, subsp. *salleana*, was taken for *P. badia*, and I never have seen an example of *Melanopsis trifasciata* from Lake Rotoiti, though I tried hard to get some. In the Lake of Tiberiade, in Palestine, *Melanopsis* has been found at a depth of about 150 ft.

From Lake Wakatipu *Planorbis corinna* and *Isidora antipodea* were not represented.

All the Mollusca living in deeper water have much lighter colours, and the test is much thinner and more fragile. With one exception (*Corneocyclas hodgkini*) there is no real deep-lake fauna in these lakes, such as it is known from the subalpine lakes in Switzerland, &c., and this may partly be explained by the poverty of our lakes in molluscan life. *Limnæa* is absent, its place being taken by *Amphipeplea*, and it is interesting to find this genus represented by one species only.

The littoral fauna, according to Forel's investigations,* extends to 50–75 ft., and it is therefore evident that many of our known species can live in deeper water without undergoing any great structural change. Generally *Unionidæ* are not found in very deep water. However, *Anodonta ponderosa*, Pfr., was obtained in 33 ft. in Lake Tschaldyr, in Armenia, by Dr. Brandt, and five species of *Unio* were dredged in 150–300 ft. in Lake Tiberiade, in Palestine, by Lortet.

Sphærium and *Isidora* have, as far as I know, not been known to live in deeper water, and of *Potamopyrgus* it is for the first time we get any accurate knowledge of the depths of water in which it may be found living.

The deep-lake molluscan fauna of New Zealand, as far as Messrs. Lucas and Hodgkin's investigations go, may be considered to be composed of the following species :—

(1.) Diplodon menziesi, *Gray*.
(2.) ,, ,, *subsp.* lucasi, *Suter*.
(3.) Sphærium novæ-zelandiæ, *Deshayes*.
(4.) Corneocyclas novozeelandica, *Prime*.
(5.) ,, hodgkini, *Suter*.
(6.) Potamopyrgus corolla, *Gould*.
(7.) ,, ,, *subsp.* salleana, *Fischer*.
(8.) Potamopyrgus badia, *Gould*.
(9.) Amphipeplea arguta, *Hutton*.
(10.) Isidora lirata, *Tenison-Woods*.

* Dr. F. A. Forel, "La Faune profonde des Lacs Suisses," 1885.

Art. XIV.—*The First-discovered New Zealand* Gundlachia.

By Henry Suter.

[*Read before the Wellington Philosophical Society, 7th September,* 1904.]

Gundlachia neozelanica, n. sp.

Ancylus, sp., Suter, Journ. de Conch., vol. xl., pp. 248–250 (1892). *Ancylus tasmanicus*, Suter, P.L.S. N.S.W. (2), vol. vii., p. 624 (1893), (not of T.-Woods). *Gundlachia*, sp., Suter, Trans. N.Z. Inst., vol. xxvi., p. 122, pl. xiv., figs. 1–5 (1894); *Gundlachia*, sp., Suter, P.L.S. N.S.W. (2), vol. viii., p. 486 (1894); *Gundlachia*, sp., Hedley, *l.c.*, pp. 505, 507, 511, pl. xxiv., figs. 12–15; *Gundlachia*, sp., Suter, Journ. de Conch., vol. xli., p. 229 (1894).

Shell depressed-conoidal, oval-oblong, thin, subtransparent, horn-colour, with a blackish-green coating; apex a little inclined to the right, situated at the posterior sixth of the length, flatly convex anteriorly; concentric lines of growth at regular intervals. Interior light-brown, shining; aperture elongated-oval, slightly broadened anteriorly. Length, 3 mm.; breadth, 2 mm.; height, $\frac{2}{4}$ mm.

Hab. River Avon, near Christchurch.

Type in my collection.

With regard to the dentition I have to rectify a mistake in the figure: the rhachidian tooth is bicuspid, not tricuspid.

The formation of a septum has been described and figured by Hedley (*l.c.*) from specimens I sent him.

I always hesitated giving this species a name, as I hoped fully developed specimens might turn up. This, however, has not been the case, and, as a second species has been discovered, it is incumbent to name the first-discovered form.

Art. XV.—*Revision of the New Zealand Species of the Genus* Potamopyrgus, *with Description of a New Species.*

By Henry Suter.

Communicated by A. Hamilton.

[*Read before the Wellington Philosophical Society, 7th September,* 1904.]

A revision of the New Zealand *Hydrobiinæ* was published by Captain F. W. Hutton in 1882,* reducing the already described

* Trans. N.Z. Inst., vol. xiv., pp. 143–146, pl. i., figs. A–H.

species to three, and adding a new species (*P. pupoides*). Hutton says: "The absence of books prevents me feeling certain that all the synonyms I have given are correct." With regard to books we are not much better off than we were twenty-two years ago, and, besides this, there is the very great inconvenience for us that the types of all the species, Hutton's species excluded, are in foreign museums. It was many years back, when material in my collection was fast accumulating, that I found Hutton's restriction to a total of only four species unsatisfactory. I am fully aware of the great variability of fresh-water molluscs, also of the fact that many species of *Potamopyrgus* are polymorphic, and therefore one and the same species may have been described under different names. There is a spinous angulate form, then an angulate espinous form, and thirdly an acuminate ecarinate one. Of the New Zealand species only two are polymorphic.

I tried to get as much information as I possibly could about those species of which I did not possess sufficient knowledge, and I have to thank especially Dr. W. H. Dall, Hon. Curator of Mollusks, U.S. National Museum, Washington; also Dr. H. Fischer, of Paris; Dr. R. Sturany and Dr. Oberwimmer, K.K. Hofmuseum, Vienna, for the great readiness with which they acceded to my request. The revision now undertaken is to a large extent based on the information thus obtained, and I hope it may prove useful to students of conchology.

The species of *Potamopyrgus* described from New Zealand up to now number eleven (omitting *crossei*, Frfld., *ciliata*, Gould, and *gracilis*, Gould, for reasons shown later on), and they were formerly classed under five genera: *Melania*, *Amnicola*, *Paludestrina*, *Hydrobia*, and *Bythinella*. These eleven species I now reduce to five, with three subspecies.

Genus POTAMOPYRGUS, Stimpson (1865); Stimpson, Amer. Journ. of Conchology, vol. i. (1865), p. 53; Smithon, Miscell. Coll., No. 201 (1865), pp. 49, 50.

Type: *Melania corolla*, Gould, Proc. Bort. Soc. Nat. Hist., vol. ii. (1874), p. 223.

Synonym: *Pyrgophorus*, Ancey, Bull. Soc. Mal. France, vol. v. (1888), pp. 188, 192.

Stimpson's diagnosis of the genus is reproduced by Hutton in Trans. N.Z. Inst., vol. xiv., p. 143, with some additional remarks on the dentition.

Pilsbry says, "*Potamopyrgus* is a genus of great antiquity, extending at least as far back as the early Eocene. It now comprises all of the fresh-water rissoids of New Zealand, a majority of those of Australia, with species in West Africa and

tropical America."* Tasmania has forms very nearly allied to ours. The genus is, as far as I am aware, not known in the fossil state from New Zealand.

Potamopyrgus corolla, Gould, sp.

Melania corolla, Gould, Proc. Bost. Soc. Nat. Hist., vol. ii. (1847), p. 223. *Melania corolla*, Reeve, Conch. Sc. (Melania), fig. 366. *Amnicola corolla*, Gould, U.S. Expl. Exp., vol. xii. (1852), p. 129, pl. ix., figs. 149 *a–c*. *Paludestrina cumingiana*, P. Fischer, Journ. de Conch., vol. viii. (1860), p. 208, pl. iv., fig. 7. *Potamopyrgus corolla*, Stimpson, Smithon. Miscell. Coll. No. 201 (1865), pp. 49, 50. *Hydrobia crossei*, Frauenfeld, Verh. Zool. Bot. Gesell. Wien, vol. xiv. (1865), p. 595. (?) *Hydrobia ciliata*, Frauenfeld, *l.c.*, p. 1025. *Bythinella corolla*, Tenison-Woods, P.L.S. N.S.W., vol. iii. (1879), p. 135, pl. xiii., figs. 2, 3, 5. *Hydrobia corolla*, v. Martens, Crit. List N.Z. Moll. (1873), p. 14. *Hydrobia corolla*, Hutton, Manual N.Z. Moll. (1880), p. 83. *Potamopyrgus cumingiana*, Hutton, Trans. N.Z. Inst., vol. xiv. (1882), p. 144, pl. i., figs. A, F. *Potamopyrgus cumingiana*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii. (1893), p. 619. *Potamopyrgus cumingiana*, Suter, Journ. de Conch., vol. xli. (1893), p. 222.

Dr. Sturany, of Vienna, kindly informed me (*in lit.*) that Frauenfeld proposed the specific name *crossei* solely in case the name of Fischer, *Paludestrina cumingiana*, should be accepted, as there exists a *Paludestrina cumingi*, d'Orb., of earlier date.

Regarding the species *Hydrobia ciliata*, Gould, I am indebted to Dr. W. H. Dall, of Washington, for the following (*in lit.*): "Described as from Liberia with other shells from the missionary Dr. Perkins, but appears very similar to Hutton's figure in Trans. N.Z. Inst., vol. xiv., pl. i., fig. B 1. It seems as if some mistake had occurred, and this shell should really have come from New Zealand, but it is difficult to see how, as Gould was a very careful man." Dr. P. Fischer no doubt admitted this species to be of African origin, for he says, "Nous connaissons deux autres espèces de la Nouvelle-Zélande, une des Antilles, une de l'Afrique; toutes sont caracterisée par la série d'épines qui ornent le dernier tour de spire."† Pilsbry also, as already stated, gives West Africa as the habitat of *Potamopyrgus*, and is most likely alluding to the above species.

Dr. W. H. Dall (*in lit.* 20, xi., 97) also kindly sent me the following information respecting the type of the genus: "*Melania*

* Proc. Acad. N. Sci., Philadelphia, 1891, p. 327.
† Journ. de Conch., vol. viii. (1860), p. 209.

corolla, Gould (1847), is not *corolla* of Hutton, but the shell figured by Reeve as *corolla*. It is the largest, with spare long spines. The locality may have been erroneous. The whorls are rounded, *cf.* Hutton, Trans. N.Z. Inst., vol. xiv., pl. i., fig. A 1." Considering this statement, we must conclude that the synonyms given by Hutton in his Manual, p. 83, are mostly correct, but that in his revision he took the wrong species for *corolla*—viz., *Amnicola badia*, Gould. He says (*l.c.*, p. 143) that *P. cumingiana*, Fischer, which is held by v. Martens to be the same species as *P. corolla*, Gould, does not occur on Banks Peninsula, and that its dentition does not correspond with the description given by Dr. Stimpson. Now, Dr. Dall admits that the locality given by Gould may have been erroneous, and this appears now to be quite certain. I examined the dentition in typical specimens of *P. corolla* from the Ruamahanga River, Wairarapa, and I cannot say that it does not agree with Stimpson's description. The rhachidian and the lateral teeth correspond with his diagnosis, but the marginal teeth have a number of larger denticles, their number agreeing with Stimpson's statement, but there are a number of minute denticles besides which I am unable to count with a magnifying-power of 720. The number of denticles on the marginal teeth is variable, and can hardly be used for specific distinction.

The diagnosis of the species is as follows: Shell horn-colour, sometimes covered with a black coating, ventricose, thin, subpellucid; 6½ rounded whorls, the last three spinous, the others smooth and sometimes of a darker colour, the last swollen, subcarinated at the encircling series of spines. Spines long, rather distant, curved, directed upwards. Aperture ovate, peristome continous, thickened. There may be only rudimentary spines, or they may be absent altogether, leaving only a carina, or, finally, all the whorls may be smooth and convex, without a trace of a carina or spines. Length, 6·5 mm.; breadth, 4·5 mm. Ratio of B : L = 1 : 1·44.

This species is distinguished by its globosely ventricose form, the absence of spines on the first 3½ whorls, the great number of spines on the last whorl (17 to 20), their length, curvature, and direction towards the apex.

My collection contains specimens from fourteen localities:—

(1.) Typical form with long spines is represented from Lakes Takapuna and Kanieri. Those from the latter locality have shorter spines. Most of the specimens are of horn-colour, sometimes with the first few whorls darker, and a few have a dark-brown coating.

(2.) Specimens with rudimentary spines occur in the creeks at Henderson and Swanson; in the creek at Hastwell's and

Ruamahanga River in the Forty-mile Bush; at Petone, near Wellington; Parua Bay, near Whangarei; and on the Chatham Islands. The majority of these specimens have a thick, black coating, and the continuous peristome much thickened.

(3.) With only a thread-like carina on the whorls there are specimens from Hastwell's and the Chatham Islands.

(4.) Shells with the whorls smooth, rounded, mostly coated with black and callous peristome, were found in creeks at Northcote, Hastwell's, Parua Bay, Kawau Island, the Waikato, and Chatham Islands.

(5.) Dwarf forms with spines, horn-colour, and six whorls, were collected in Lake Takapuna (3½ × 4½ mm.), and near Greymouth (4 × 6 mm.).

Type in the U.S. Nat. Mus., Washington.

Potamopyrgus corolla, Gould, subsp. **salleana**, P. Fischer, subsp.

Paludestrina salleana, P. Fischer, Journ. de Conch, vol. viii. (1860), pp. 208, 209, pl. iv., fig. 6.

Shell horn-colour, conical, thin; whorls 7 to 7½, flatly convex, the last four spinous, the others smooth, the last whorl with a chordate carina below the row of spines. The setæ are short, black, directed upwards. Aperture ovate, margins continuous, but little callous. Length, 6 mm.; breadth, 3½ mm. Ratio of B : L = 1 : 1·7.

This subspecies differs from *corolla* in being more slender, less ventricose, in having spines on the last four whorls and a chordate carina below the row of spines; the last whorl is also less voluminous in proportion.

Although I have examined many hundreds of specimens I have not yet seen one with a chordate carina below the row of setæ, but some specimens from the Great Barrier Island and from Nelson are distinctly angled below the periphery, and I take this quite peculiar character mentioned by Fischer as of quite exceptional occurrence.

The distribution of this subspecies extends over a large area. In my collection there are specimens from Lake Takapuna, Western Springs (Auckland), Lake St. John, Onehunga Springs, Great Barrier Island, Maketu (Hunua Range), Waipoua River (near Masterton), Petone (near Wellington), Pelorus River, Nelson, and Collingwood.

All specimens are yellowish-brown, thinner than *corolla*, mostly without spines, and some are larger than the type. Length, 8 mm.; breadth, 4½ mm. The Nelson specimens are from brackish water.

Type in the collection of the Journal de Conchyliologie, Paris.

Potamopyrgus antipodum, Gray, sp. (em.).

Amnicola antipodanum, Gray, in Dieffenbach's "New Zealand," vol. ii. (1843), p. 241. *Hydrobia antipodum*, v. Martens, Crit. List N.Z. Moll. (1873), p. 14. *Hydrobia antipodum*, E. A. Smith, Voy. "Erebus" and "Terror," Zool., vol. ii. (1875), p. 3, pl. i., fig. 19, above. *Bythinella antipoda*, Hutton, Manual N.Z. Moll. (1880), p. 81. *Potamopyrgus antipodum*, Hutton, Trans. N.Z. Inst., vol. xiv. (1882), p. 145, pl. i., figs. C, G (except upper right figure). *Potamopyrgus antipodum*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii. (1893), p. 619. *Potamopyrgus antipodum*, Suter, Journ. de Conch., vol. xli. (1893), p. 221.

The statement made by v. Martens (*l.c.*, p. 141) that "some specimens are bristly" is not correct. This species has never been found with spines or a carina.

The diagnosis of the species may be found in Hutton's Manual, and in Trans. N.Z. Inst., vol. xiv.

P. antipodum is just as variable as most species of the genus, especially in size; but the conical form, flatly convex whorls, and little-impressed suture are fairly constant characters.

I have specimens from twelve localities, ranging from Auckland to Southland. Specimens from Owaka (Clutha) are very small and ventricose, with five whorls only, and measuring $4\frac{1}{2} \times 2\frac{3}{4}$ mm. Another dwarf form was collected by Mr. R. Murdoch, of Wanganui, on the Waimate Plains.

The great majority of the specimens are covered with a black coating. It is remarkable that *P. antipodum* is very often met with in brackish water, and almost without an exception such specimens have the tip of the shell eroded. In some places I saw this species living on *Ulva* plants. I have specimens from brackish water from seven different localities.

Type in the British Museum.

Potamopyrgus antipodum, Gray, subsp. zelandiæ, Gray, subsp.

Amnicola (?) *zelandiæ*, Gray, in Dieffenbach's "New Zealand," vol. ii. (1843), p. 241. *Hydrobia zelandiæ*, v. Martens, Crit. List. N.Z. Moll. (1873), p. 15. *Hydrobia zelandiæ*, E. A. Smith, Voy. "Erebus" and "Terror," Zool., vol. ii. (1875), p. 3, pl. i., fig. 19, below. *Bythinella zelandiæ*, Hutton, Manual N.Z. Moll. (1880), p. 81.

This subspecies is fairly well represented by the upper right figure on pl. i., fig. C, in Trans. N.Z. Inst., vol. xiv. It is distinguished from the species by its somewhat smaller size and more tapering form. Dimensions of type are: Length, 5 mm.; breadth, $2\frac{1}{2}$ mm. It is much rarer than *antipodum*, but also shows a good amount of variation.

My collection contains specimens from Nelson, three localities near Wellington, Wanganui, Hastwell's, and Riverhead (near Auckland), the latter being from brackish water, and small.

Type in the British Museum.

Potamopyrgus badia, Gould, sp.

Amnicola badia, Gould, Proc. Bost. Soc. Nat. Hist., vol. iii. (1848), p. 75; U.S. Expl. Exp., vol. xii. (1852), p. 126, fig. 150. *Hydrobia fischeri*, Dunker, Mal. Blätter, vol. viii. (1862), p. 152. *Hydrobia reevei*, Frauenfeld, Verh. Zool. Bot. Gesell. Wien, vol. xiii., p. 1024. *Hydrobia fischeri, badia, reevei*, v. Martens, Crit. List. N.Z. Moll., pp. 14, 15. *Bythinella fischeri, badia, reevei*, Hutton, Manual N.Z. Moll. (1880), p. 82. *Potamopyrgus corolla*, Hutton, Trans. N.Z. Inst., vol. xiv. (1882), p. 145, pl. i., figs. B, F (not of Gould). *Potamopyrgus corolla*, Hedley and Suter, P.L.S. N.S.W. (2), vol. viii. (1893), p. 619 (not of Gould). *Potamopyrgus corolla*, Suter, Journ. de Conch., vol. xli. (1893), p. 619 (not of Gould).

The type of this species is not spiny, the whorls moderately convex, shouldered above, and the dimensions given are: Length, $\frac{1}{5}$ in. = 5 mm.; breadth, $\frac{1}{12}$ in. = 2 mm.; ratio of B : L = 1 : 2·5.

This is the species that since 1882 was erroneously called *corolla* by New Zealand conchologists. I have specimens from the River Avon which perfectly agree with the description and measurement given by Gould. Some are spinous, some shouldered and without spines, and others have smooth, flatishly rounded whorls. These typical specimens are, according to my experience, very rare, and it is curious that this form, instead of the very common one, should have been collected. The common form has the following dimensions—length, 5 mm.; breadth, 2½–3 mm.—having thus a somewhat greater angle of the spine. Both forms were found living together in the River Avon.

I know this species from the South Island only, and the finest specimens I found in the Rivers Avon and Heathcote, near Christchurch. Specimens from Akaroa have smooth, rounded whorls; a globose form, also smooth, and measuring 4½ × 3 mm., comes from Kowai Bush. Similar smooth forms are in my collection from Mount Somers, Bealey, Birch Hill (Tasman Valley), and Opawa, near Albury, the latter agreeing with *H. fischeri*. From the Leith, Dunedin, smooth and spinous forms are mixed, but the former are more abundant. I mentioned the occurrence of a large form of *P. cumingiana* from Lake Te Anau in these Transactions (vol. xxvi., p. 121), measuring 8 × 4 mm. Careful

examination and comparison have now convinced me that it is really a very large form of *P. badia*.

Considering the great variability of *Potamopyrgus* I refrain from establishing any new species or subspecies unless for very good reasons, and merely mention the localities where forms differing considerably from the type have been found. Temperature, chemical composition, movement and size of the water-area, and food available have a great influence on the growth of fresh-water shells, and it is difficult to find the same form of a species in more than two or three localities. Taking into consideration the polymorphism of some species, and the great variability, we can congratulate ourselves on having not more synonyms to record.

Type in the U.S. Nat. Museum, Washington.

Potamopyrgus egenus, Gould, sp.

Amnicola egena, Gould, Proc. Bost. Soc. Nat. Hist., vol. iii. (1848), p. 75. *Amnicola gracilis*, Gould, U.S. Expl. Exp., vol. xii. (1852), p. 127, figs. 151 *a*, *b*. *Hydrobia egena*, v. Martens, Crit. List. N.Z. Moll. (1873), p. 15. *Bythinella egena*, Hutton, Manual N.Z. Moll. (1880), p. 82.

I am indebted to Dr. W. H. Dall for the following information (*in lit.*): "The shell first described by Gould as *Amnicola egena* is imperfect. It was inadvertently called *gracilis* in the final report. It appears to be identical with specimens called *gracilis* in the collection, except that the type is brown and the others greenish." Gould's diagnosis is copied in Hutton's Manual, and the type was found on Banks Peninsula.

This is undoubtedly a good species, but it seems to be rather rare. I have it in my collection from three localities only: Two specimens from Kaiwarra River, near Wellington; one from Nelson; and fourteen from Little River, Banks Peninsula. The graceful elongated shape, the convex whorls, and the last whorl amounting to half the length of the shell, distinguish it at once from the other species. No carinated or spinous forms are known. The dimensions given by Gould are: Length, 5 mm.; breadth, 2½ mm.; with five whorls. The dimensions of the Little River specimens, with five whorls, are 4 × 2 mm.; those of the Kaiwarra specimens, 4 × 1¾ mm. with six whorls, and 5 × 2¼ mm. with seven whorls; while the Nelson specimen measures 5½ × 2½ mm., and has six whorls. Thus my specimens must have slightly shorter whorls and a somewhat narrower spire than the type. In all specimens the last whorl is a trifle longer than half the axis of the shell.

Type in the U.S. Nat. Museum, Washington.

Potamopyrgus spelæus, Frauenfeld, sp.

Hydrobia spelæa, Frauenfeld, Verh. Zool. Bot. Gesell. Wien, vol. xiii. (1862), p. 1022; vol. xv., p. 526, pl. viii. *Hydrobia spelæa*, v. Martens, Crit. List. N.Z. Moll. (1873), p. 15. *Bythinella spelæa*, Hutton, Manual N.Z. Moll. (1880), p. 82.

This species was found together with *P. reevei* in moa-bone caves. A translation of the diagnosis is given by Hutton, but the dimensions are not quite those of Frauenfeld; the type is 3 mm. long by 1·6 mm. in breadth. This minute species is nearly allied to *pupoides*, Hutton, which, however, is mostly, but not always, smaller, and constantly of pupoid form.

The specimens in my collection I take to be almost typical were collected by Mr. A. Hamilton, now Director of the Colonial Museum, in the salt springs at Te Mahia, Hawke's Bay, and they show the same dimensions as the type specimen. A rather large form comes from the tidal part of the Wanganui River, and its dimensions vary from 3 × 1¾ mm. to 3½ × 2 mm. Very small specimens occur at Nelson, the largest measuring 2½ × 1¼ mm., the smallest 2 × 1 mm. The latter is the usual size of *P. pupoides*, but the Nelson examples are distinguished by much more convex whorls, deeper suture in consequence, and a more conoidal spire. Forms with ventricose body-whorl were collected by Mr. Chadwick on the upper Wanganui River, and in a cold mineral pool at Rotorua by Lady Frances Brown, a most enthusiastic collector. What I consider to be the same species are examples collected by Mr. Charles Cooper, of Auckland, in hot-spring water at Te Aroha. These specimens are very variable in shape, some approaching the type and measuring 3 × 1½ mm., others with a more inflated body-whorl show ½ mm. greater breadth; they all have only four whorls. This is the only instance known to me of a mollusc living in hot water in New Zealand, while it is well known that *Neritina* and *Bithynia* have been found in France living in water from 68° to 122° Fahr.

Type in the K.K. Hofmuseum, Vienna.

Potamopyrgus spelæus, Frfld., subsp. pupoides, Hutton.

Potamopyrgus pupoides, Hutton, Trans. N.Z. Inst., vol. xiv. (1882), p. 146, pl. i., figs. D–H. *Potamopyrgus pupoides*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii. (1893), p. 620. *Potamopyrgus pupoides*, Suter, Journ. de Conch., vol. xli. (1893), p. 222.

I have typical specimens from brackish water in the Heathcote Estuary, near Christchurch, and they are so nearly allied to Frauenfeld's *spelæus* that I find it advisable to give *P. pupoides* only subspecific rank. It is distinguished from the species

by its cylindrical form, the much flatter whorls, and the less impressed suture. I have also specimens from Parua Bay, near Whangarei, and from the Onehunga Springs. Those from the latter locality are variable, some corresponding with the type, while others have more convex whorls, and approach the very small form of *spelæus* from Nelson.

Type in the Canterbury Museum, Christchurch.

Potamopyrgus subterraneus, n. sp.

Shell minute, subcylindrical, fragile, opaque-white, smooth. Spire pupoid; apex blunt; whorls 5, rather convex, the body-whorl more than half the axis; suture well impressed; mouth oval, oblique, peristome continuous; outer lip membranaceous, the specimen being apparently not quite full-grown; inner lip slightly callous, subvertical. Operculum not seen. Length, 2¾ mm.; breadth, 1¼ mm.

Hab. The only specimen was obtained by Mr. W. W. Smith, of Ashburton, by pumping water from a well 48 ft. deep.

It was alive when caught, but upon reaching me the animal was already decomposed. Mr. Smith very kindly presented the specimen to me in February, 1892. I did not describe it then because I hoped to get some specimens with the animal in sufficiently good condition for study. No other specimens, however, turned up. The species is exceedingly fragile, and distinguished, like *pupoides*, by its subcylindrical form. The nearest allies are *egenus* and *spelæus*, but it differs considerably from both. It most likely has been derived from the latter species.

Type in my collection.

ART. XVI.—*Revision of the New Zealand Species of the Genus* Isidora, *with Description of a New Subspecies.*

By HENRY SUTER.

Communicated by A. Hamilton.

[*Read before the Wellington Philosophical Society, September 7th*, 1904.]

THE first short list of species we find in von Marten's "Critical List" (1873), p. 15, consisting of three species: *Physa variabilis*, Gray; *P. tabulata*, Gould; and *Limnæa* (?) *wilsoni*, Tryon (a sinistral shell). The next list, in Hutton's Manual, is more extensive, comprising ten species: *Physa wilsoni*, Tryon; *P. antipodea*, Sow.; *P. gibbosa*, Gould; *P. guyonensis*,

T.-Woods; *novæ-zelandiæ*, Sow.; *P. tabulata*, Gould; *P. variabilis*, Gray; *P. moesta*, Ad.; *P. lirata*, T.-Woods; and *P. cumingii*, Ad. In vol. vii., P.L.S. N.S.W., Captain Hutton published a list of the fresh-water shells of New Zealand, in which the species of the genus were reduced to four—*Aplexa antipoda*, Sow.; *A. tabulata*, Gould; *A. variabilis*, Gray (= *gibbosa*, Sow. not Gould, *guyonensis*, T.-Woods, *hochstetteri*, Dkr.); and *A. moesta*, Ad. In 1885 Captain Hutton gave a list of the *Limnæidæ* in these Transactions, vol. xvii., enumerating *Bulinus antipodeus*, Sow.; *B. variabilis*, Gray (= *gibbosus*, Hutt. *non* Gould, *novæ-zealandiæ*, Sow., *guyonensis*, T.-Woods); *B. tabulatus*, Gould; and *B. moesta*, Adams (= *lirata*, T.-Woods), giving a description and figure of the dentition of the latter. The following species were omitted as not really inhabiting New Zealand: *Limnæa wilsoni*, Tryon, like *Physa pyramidata*, Sow., from Australia; *Physa gibbosa*, Gould, inhabiting New South Wales; and *Physa cumingi*, Ad., inhabiting Queensland.

In Fischer's Manual, p. 257, we find only two species recorded: *Physa guyonensis* and *P. moesta*. With my friend Mr. Charles Hedley, of Sydney, I published in 1893 a "Reference List of the New Zealand Land and Fresh-water Shells," in which, for the species of *Isidora*, Hutton's latest classification was chiefly adopted, reducing, however, the species to three: *Bulinus antipodeus*, Sow.; *B. variabilis*, Gray (= *guyonensis*, T.-Woods, *novæ-zelandiæ*, Sow.); and *B. tabulatus*, Gould (= *moesta*, Adams, *lirata*, T.-Woods). Mr. Hedley added the following species, which for want of literature had escaped the notice of New Zealand conchologists: *B. novæ-seelandiæ*, Clessin; *tenisoni*, Clessin; *coromandelicus*, Dkr.; and *hochstetteri*, Dkr.

The following year I published, at the request of Mr. H. Crosse, a somewhat more extensive list in the Journ. de Conch., vol. xli., adhering still to three species of *Isidora*, and reducing Clessin's and Dunker's species to synonyms, as follows: *Bullinus variabilis*, Gray (= *guyonensis*, T.-Woods, *novæ-zelandiæ*, Sow., *gibbosus*, Hutt. *non* Gould, *novæ-seelandiæ*, Clessin); *B. tabulatus*, Gould (= *moesta*, H. Ad., *lirata*, T.-Woods, *coromandelicus*, Dkr., *hochstetteri*, Dkr.); and *B. antipodeus*, Sow.

I have studied now the description and copy of figure, kindly supplied to me by Mr. Hedley, of *Physa novæseelandiæ*, Clessin, and find it to be identical with *Physa lessoni*, E. A. Smith, an Australian shell, and it has therefore to be omitted from the list of New Zealand shells. *Physa tenisoni*, Clessin, is according to the figure a *Limnæa*, being dextral. *Physa hochstetteri*, Dunker, was mentioned by Hutton as a synonym of *Aplexa variabilis*, Gray (*antea*), but was never mentioned again in his later publications.

When working out the Mollusca collected by Mr. K. Lucas in New Zealand lakes, I had the same experience with *Isidora* as with *Potamopyrgus*: the lumping of species had been carried on too far. I do not wish to exonerate myself from blame, and I freely confess that never before have I made a careful study of our species of *Isidora*, as their great variability makes it extremely difficult to decide the limit of species and subspecies. A good collection of specimens from various localities, besides plenty of time and patience, is necessary for the successful study of these fresh-water molluscs. Specimens from over twenty localities were used to write the present revision, and I hope that it will form a sound basis to work upon.

Physa variabilis was the first species described by Gray (in "Dieffenbach's Travels," vol. ii. (1843), p. 248). The very short diagnosis, unaccompanied by a figure, has in my opinion been the curse of New Zealand conchologists. From the many species judged to be synonyms of this unfortunate *variabilis* it can be gathered that no one ever knew what Gray's species is—perhaps not even Gray himself, for his diagnosis fits nearly all our species. So it has become a regular *olla podrida:* all the forms that did not fall under a recognised species were simply labelled "*variabilis*, Gray." I have come to the conclusion that as long as we retain this species there is no possibility of classifying our various forms of *Isidora* correctly, and I reject it as insufficiently described, unfigured, and embracing perhaps several distinct species.

Genus ISIDORA, Ehrenberg (1831).

Synonyms: *Diastropha*, Gray (1840); *Ameria*, H. Adams (1861); *Glyptophysa*, Crosse (1872); *Pyrgophysa*, Crosse (1879); *Physastra*, Tapparone Canefri (1883).

Animal without the produced and reflected mantle-lobes of *Physa*; radula Limnæidian, approaching *Planorbis* rather than *Limnæa*; central tooth bicuspid, cusps rather blunt, base square; laterals tricuspid; marginals serrate. Laterals about 6–10, marginals about 25–33. Number of rows varying between 140 and 220.

Shell sinistral, resembling that of *Physa*, acuminated or gibbous, smooth or keeled; texture somewhat thick, covered with a deciduous epidermis; columella strong, often reflected, umbilicus sometimes very wide and deep.

Distribution: Australia, Tasmania, New Zealand, New Guinea, New Caledonia, Fiji, Tonga, Africa (north, north-east, west, and south), southern France, Spain, and all countries bordering the Mediterranean.

Ameria was proposed for *Physæ* with keeled whorls. The

distinction is untenable. Every gradation of keeling is observable in the Australian *Isidoræ* (Rev. A. H. Cooke).

Isidora tabulata, Gould (1848), sp.

Physa tabulata, Gould, Proc. Boston Soc. Nat. Hist., vol. ii. (1848), p. 214; U.S. Expl. Exp., vol. xii., p. 116, figs. 136 *a*, *b*. *Physa tabulata*, v. Martens, Crit. List N.Z. Moll. (1873), p. 15. *Physa tabulata*, Hutton, Man. N.Z. Moll. (1880), p. 30. *Aplexa tabulata*, Hutton, P.L.S. N.S.W., vol. vii., p. 67. *Bulinus tabulatus*, Hutton, Trans. N.Z. Inst., vol. xvii. (1885), p. 57. *Physa tabulata*, A. H. Cooke, P.Z.S. (1889), pp. 139, 140, fig. 4 (radula). *Bulinus tabulatus*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii. (1893), p. 627. *Bullinus tabulatus*, Suter, Journ. de Conch., vol. xli. (1894), p. 233.

Fig. 1.

The diagnosis is to be found in Hutton's Manual. Fig. 1 represents the species after a copy from Reeve (Conch. Icon., vol. xix., *Physa*, fig. 17*b*), kindly supplied with several others by Mr. Hedley. Taken from the figure the dimensions are—Shell: length, 22 mm.; breadth, 16 mm. Aperture: length, 12 mm.; breadth, 8 mm. I think it to be a most useful thing to establish the following rationis to help in separating the various forms: i. Ratio between breadth and length of shell = 1 : 1·4; ii. ratio between breadth and length of aperture = 1 : 1·5; iii. ratio between length of aperture and length of shell = 1 : 1·8. Hereafter I shall designate these rationis simply by i., ii., iii.

Hab. A mountain-stream, Bay of Islands (Drayton).

Type in the U.S. Nat. Museum, Washington.

I have not seen this species.

Isidora tabulata, Gould, subsp. **moesta**, H. Adams (1861), subsp.

Physa moesta, H. Adams, P.Z.S. (1861), p. 144. *Physa coromandelica*, Dunker, Malac. Blätter (1862), p. 150. *Physa moesta*, Hutton, Man. N.Z. Moll. (1880), p. 31. *Aplexa moesta*, Hutton, P.L.S. N.S.W., vol. vii., p. 67. *Bulinus moesta*, Hutton, Trans. N.Z. Inst., vol. xvii., p. 57, pl. xii., fig. 12 (dentition). *Bulinus moesta et coromandelica*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii., pp. 627, 628. *Bullinus moesta et coromandelica*, Suter, Journ. de Conch., vol. xli., p. 233.

Fig. 2.

The very short diagnosis is fortunately supplemented by a figure in Reeve's Conch. Icon., fig. 32, the outlines of which I here reproduce (fig. 2). The dimensions, taken from the figure, are—Shell: length, 17 mm.; breadth, 11 mm. Aperture: length, 10 mm.; breadth, 5 mm. The proportions are: i. = 1 : 1·5; ii. = 1 : 2; iii. = 1 : 1·7.

I have examined and measured specimens in my collection from the following localities :—

(1.) Ditch near Lake Takapuna, Auckland. The specimens are fuscous, with a ferrugineous coating, shouldered, larger and more slender than the type. Two specimens measured gave length of shell 15 mm. and 17 mm., breadth 9 mm.; and the mean proportions were found to be—i. = 1 : 1·8; ii. = 1 : 2; iii. = 1 : 1·7.

(2.) From Lake Takapuna, Auckland. Two specimens, dark-brown, strongly carinated, larger and a little less ventricose than the type. Shell: length, 12–15½ mm.; breadth, 7–9 mm. Mean rationis—i. = 1 : 1·7; ii. = 1 : 2; iii. = 1 : 1·5.

I first tried to uphold *I. coromandelica*, Dunker, as a separate subspecies of *I. tabulata*, as the specimens of the above three localities approach the ratio between breadth and length of shell of *I. coromandelica*, which is 1 : 2, but I soon found out that all intermediate forms, from the elongated *coromandelica* to the more ventricose *moesta*, are met with, and, as there seems to be no other character available to distingusih the two, I thought it advisable to make the former a synonym of the latter.

(3.) Wanganui (no exact locality). One adult and two not quite full-grown specimens were measured. The adult had—length, 17 mm.; breadth, 10 mm. All specimens are shouldered. The mean proportions are—i. = 1 : 1·6; ii. = 1 : 2·1; iii. = 1 : 1·4.

(4.) Fresh-water stream, Parua Bay, Whangarei. All specimens are blackish-brown, two are distinctly shouldered, the other has smooth whorls. The columellar fold is very distinct. Three shells showed the length to vary from 9–15 mm., the breadth from 5½–9½ mm. The mean proportions are—1 = 1 : 1·7; ii. = 1 : 1·9; iii. = 1 : 1·6.

(5.) Waikato River, near Huntly. Shells of good size, chestnut-colour, some with a ferrugineous coating; young specimens are strongly carinated, in adult specimens the carina is reduced to a slight angulation on the last whorl. Columella strongly twisted. Four shells were measured, the length being 12–15 mm.; breadth, 8–11 mm. The mean proportions were—i. = 1 : 1·4; ii. = 1 : 1·9; iii. = 1 : 1·5.

(6.) Chatham Islands. One specimen only, of yellowish-brown colour, with four shouldered whorls. This is a slender form. Length, 8 mm.; breadth, 4½ mm. Rationis—1 = 1 : 1·8; ii. = 1 : 2; iii. = 1 : 1·6.

The result of measuring twenty-eight specimens is the following: Ratio i.—variability, 1 : 1·4 to 1 : 1·8; mean, 1 : 1·65. Ratio ii.—variability, 1 : 1·9 to 1 : 2·3; mean, 1 : 2. Ratio iii.—variability, 1 : 1·4 to 1 : 1·7; mean, 1 : 1·5. It shows that the shells of this subspecies are a little more slender and the spire

is somewhat higher in proportion to the length of the aperture than in the type specimen figured.

Type in the British Museum (?).

Isidora hochstetteri, Dunker (1862), sp.

Physa hochstetteri, Dunker, Malac. Blätter, vol. ix. (1862), p. 150. *Physa guyonensis*, T.-Woods, P.L.S. N.S.W., vol. iii. (1879), p. 138, pl. xiii., fig. 4. *Physa guyonensis*, Hutton, Man. N.Z. Moll., p. 30. *Physa guyonensis et hochstetteri*, Hutton, P.L.S. N.S.W., vol. vii., p. 67. *Bulinus guyonensis et hochstetteri*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii., pp. 627, 628. *Bullinus guyonensis et hochstetteri*, Suter, Journ. de Conch., vol. xli., pp. 232, 233.

The diagnosis of *guyonensis* is in Hutton's Manual. The accompanying fig. 3 is drawn from a tracing of the figure given by Tenison-Woods. Captain Hutton mentions (Manual) that Dr. Dohrn determined specimens from the same locality (Lake Guyon) as *P. hochstetteri*, Dkr. The diagnosis agrees in the main points with that of T.-Woods, and Dunker particularly mentions the deep suture and the amplitude of the body-whorl. I do not hesitate to accept the determination of the distinguished conchologist, Dr. Dohrn. The dimensions of *P. hochstetteri* are—Height, 17 mm.; breadth, 9 mm. For *P. guyonensis* the dimensions given by T.-Woods are—Height of shell, 15 mm.; breadth, 7½ mm.: aperture—height, 9 mm.; breadth, 5 mm. I have not seen specimens from Lake Guyon, but I have shells from Lake Nga-tu, Kaitaia, which I consider to belong to this species, although they are somewhat shorter and more ventricose than the type; otherwise they agree with the diagnosis. Especially the deep suture is characteristic, no other of our species showing this character in such a marked degree. All my examples are "dead shells" of a light-brown colour.

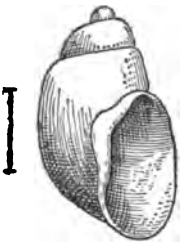


Fig. 3.

For *I. guyonensis* the rationis are—i. = 1 : 2; ii. = 1 : 1·8; iii. = 1 : 1·7. For *hochstetteri*—i. = 1 : 1·9. I measured four of my specimens. The length of the shell varies from 13½–14½ mm., the breadth from 8–9 mm. Aperture—length, 8–9 mm.; breadth, 4–5 mm. The mean proportions are—i. = 1 : 1·6; ii. = 1 : 1·9; iii. = 1 : 1·6.

Hab. The only localities known to me are Lake Guyon, Nelson, and Lake Nga-tu, in the high north.

Type in the K.K. Hofmuseum, Vienna (?).

Isidora novæ-zelandiæ, Sowerby (1873), sp.

Physa novæ-zelandiæ, Sowerby, Reeve, Conch. Icon., vol. xix., *Physa*, sp. 29 (1873). *Physa novæ-zealandiæ*, Hutton, Man. N.Z. Moll., p. 30. *Bulinus novæ-zelandiæ*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii., p. 627. *Bullinus novæ-zelandiæ*, Suter, Journ. de Conch., vol. xli., p. 232.

The diagnosis of this species is also contained in Hutton's Manual, and I reproduce here a figure (4) from a tracing of fig. 29*b* in Conch. Icon. Taken from the figure the dimensions are—Shell: length, 20½ mm.; breadth, 12¼ mm. Aperture: length, 15 mm.; breadth, 6 mm. Proportions — i. = 1 : 1·7; ii. = 1 : 2·5; iii. = 1 : 1·4.

Fig. 4.

I have only two specimens from the North Island, exact locality unknown. One adult specimen has smooth whorls, the other, not full-grown, is shouldered. The dimensions are — Shell: length, 17 mm.; breadth, 12 mm. Aperture: length, 14 mm.; breadth, 6½ mm. Shell: length, 14 mm.; breadth, 9½ mm. Aperture: length, 10 mm.; breadth, 4½ mm. The mean proportions — i. = 1 : 1·5; ii. = 1 : 2·2; iii. = 1 : 1·3. The adult specimen is of chestnut-colour, the young horny-olive. The spire is shorter and the last whorl not quite so broad posteriorly, nor so flat at the periphery, as the figure of the type indicates.

Type in Mr. Sowerby's cabinet (?).

Isidora antipodea, Sowerby (1873), sp.

Physa antipodea, Sowerby, Reeve, Conch. Icon., vol. xix., *Physa*, sp. 37 (1873). *Physa antipodea*, Hutton, Man. N.Z. Moll., p. 30. *Aplexa antipoda*, Hutton, P.L.S. N.S.W., vol. vii., p. 67. *Bulinus antipodeus*, Hutton, Trans. N.Z. Inst., vol. xvii., p. 56. *Bulinus antipodeus*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii., p. 627. *Bullinus antipodeus*, Suter, Journ. de Conch., vol. xli., p. 233.

Diagnosis in Hutton's Manual. I reproduce here (fig. 5) the outlines of the species after Reeve. This seems, as far as our scanty knowledge goes, to be the only one of our species that has constantly smooth whorls. The dimensions taken from the figure are—Shell: length, 22 mm.; breadth, 12 mm. Aperture: length, 13 mm.; breadth, 6½ mm. Rationis — i. = 1 : 1·8; ii. = 1 : 2; iii. = 1 : 1·7.

Fig. 5.

This species is represented in my collection by two specimens from Lake Wakatipu, and the dimensions are — Shell: length, 17 mm.; breadth, 10½ mm. Aperture: length, 11 mm.; breadth, 5½ mm. Shell: length, 18½ mm.; breadth, 11 mm. Aperture: length, 12 mm.; breadth,

6 mm. Mean rationis — i. = 1 : 1·7 ; ii. = 1 : 2 ; iii. = 1 : 1·5. These specimens are slightly more ventricose and have the aperture in proportion shorter than the type.

Hab. Lake Hayes, Otago ; near Napier ; Lake Wakatipu.

Type in Mr. Sowerby's cabinet (?).

Isidora lirata, Tenison-Woods (1879), sp.

Physa lirata, T.-Woods, P.L.S. N.S.W., vol. iii. (1879), p. 138, pl. xiii., fig. 6. *Physa lirata*, Hutton, Man. N.Z. Moll., p. 31 ; Trans. N.Z. Inst., vol. xvii., p. 57. *Bulinus liratus*, Hedley and Suter, P.L.S. N.S.W. (2), vol. vii., p. 627. *Bullinus liratus*, Suter, Journ. de Conch., vol. xli., p. 233.

The diagnosis is also in Hutton's Manual, and the accompanying fig. 6 is reproduced from T.-Wood's figure.

Fig. 6.

Fig. 6*a* shows a few teeth of the radula : the rhachidian tooth is bicuspid, the laterals tricuspid, the following transition teeth with four and more denticles, and the marginals are elongate and serrate.

This is one of the best-characterized species ; the fine spiral lirae and the anteriorly produced lip distinguish it at once from all the other New Zealand species. The dimensions given by T.-Woods are — Shell : length, 10 mm. ; breadth, 5 mm. Aperture : length, 5 mm. ; breadth, 3 mm. The proportions are — i. = 1 : 2 ; ii. = 1 : 1·7 ; iii. = 1 : 2 : but taken from the figure we get — i. = 1 : 1·9 ; ii. = 1 : 2·2 ; iii. = 1 : 1·5.

Fig. 6*a*.

In my collection the species is represented from twelve localities : Rivers Heathcote and Avon, creek in St. Albans, pond in Fendalton, all near Christchurch ; Wellington ; Greymouth ; Pelorus River ; pond near Lake St. John ; Toko ; Lakes Virginia and Westmere, near Wanganui ; and North Island, exact locality unknown. The specimens vary a great deal in size and proportions, but the main features mentioned above are always present. The colour is usually light-horny, the whorls are sometimes smooth but mostly strongly carinated, and the carina usually adorned with short light-brown bristles, a character only met with in this species.

I measured altogether thirty-one specimens and found the rationis to vary—i., from 1 : 1·6 to 1 : 1·9 ; ii., from 1 : 1·6 to 1 : 2·4 ; iii., from 1 : 1·3 to 1 : 1·7. The means are as follows—i. = 1 : 1·7 ; ii. = 1 : 1·9 ; iii. = 1 : 1·5.

Type where ?

Isidora lirata, T. Woods, subsp. conferta, n. subsp.

Shell globosely ovate, sinistral, corneous-translucent, thin, almost imperforate, the columellar reflexion leaving only a narrow chink. The distant lines of growth are rather regular, especially on the upper whorls, and under the lens fine regular and close spiral liræ are visible. The colour varies from very light horny to light olive-brown. The spire is short, about one-third the length of the shell. The pullus is acuminate, of darker colour, consisting of two whorls with fine incremental striation. There are four whorls, either strongly shouldered or having only a posterior angle, which usually gets lost on the body-whorl; the latter is forming the greater part of the shell. The base is convex, the suture impressed. Aperture vertical, elongately oval, acuminate above and produced anteriorly. The outer lip is regularly rounded, sharp, thin; the inner lip is twisted, forming a distinct fold near the axis of the shell; not much reflexed. Fig. 7 represents a distinctly shouldered form, and fig. 8 with only a slight angulation on the whorls.

Fig. 7.

Fig. 8.

This subspecies is distinguished from the species by its ventricose form and the much broader aperture, approaching *T. tabulata*, Gould. I have specimens from two localities :—

(1.) From swamps near Otorohanga, King-country. These are strongly keeled (fig. 7). Three specimens were measured—Shell: length, 11 mm.; breadth, 7 mm. Aperture: length, 7 mm.; breadth, 4 mm. Shell: length, 9½ mm.; breadth, 6½ mm. Aperture: length, 6½ mm.; breadth, 3½ mm. Shell: length, 9½ mm.; breadth, 6 mm. Aperture: length, 6 mm.; breadth, 3¼ mm. The mean rationis are—i. = 1 : 1·6; ii. = 1 : 1·7; iii. = 1 : 1·6.

(2.) From Wairau River, south of Birch Hill Station, Nelson. These specimens are much lighter in colour, the upper whorls slightly angled (fig. 8). Three specimens were measured—Shell: length, 11–12 mm.; breadth, 7–7½ mm. Aperture: length, 8–8½ mm.; breadth, 4½ mm. The mean proportions are—i. = 1 : 1·6; ii. = 1 : 1·9; iii. = 1 : 1·4. The means for the two localities are—i. = 1 : 1·6; ii. = 1 : 1·8; iii. = 1 : 1·5.

Type in my collection.

To repeat, the following species are omitted :—

(1.) ***Physa variabilis***, Gray, insufficiently described and unfigured.

(2.) ***Physa gibbosa***, Gould, inhabits Australia.

(3.) ***Physa cumingi***, H. Ad., inhabits Australia.

(4.) ***Physa wilsoni***, Tryon, inhabits Australia; perhaps *pyramidata*, Sow.

(5.) ***Physa novæseelandiæ***, Clessin = *P. lessoni*, E. A. Smith, Australia.

ART. XVII.—*Some New Species of New Zealand Marine Shells, together with Remarks on some Non-marine Species, and some Additions to the "Index Faunæ."*

By Rev. W. H. WEBSTER, B.A.

[*Read before the Auckland Institute, 27th February*, 1905.]

Plates IX. and X.

NEW SPECIES OF NEW ZEALAND MARINE SHELLS.

Turbo (Lunella) radina (= delicate), n. sp. Fig. 1, *a*, *b*.

Shell flat-topped, whorls 3½, of which the slightly depressed, white, smooth protoconch claims 1½, the next half-whorl, which is slightly rounded, is pale-green, the last is pale-brown. In the neanic stage the sharply angled periphery shows small white projections increasing in size until each assumes the form of a blunt hollow spine, having a dark-grey patch in front of it. The upper surface of the body-whorl slopes sinuously to the keeled periphery, below which are two similar but less developed keels; a single but obscure keel surrounds the deep umbilicus. The entire shell is irregularly but closely radiately striate, the striæ on the upper surface sloping backward. Suture well marked, aperture not continuous, circular, interior iridescent with a white margin inside the aperture. Columella vertical, curved, white, margin reflexed, outer lip thin. Height, 1½ mm.; breadth, 2½ mm. The operculum is characteristic.

Hab. Takapuna.

Type in my collection.

The colour and size of this shell agree with that of half a dozen specimens in my collection, also with a living specimen found at Whangarei by Mr. C. Cooper.

Astralium pyramidale, n. sp. Fig. 2, *a*.

Shell a pyramid with straight sides, brown above, marbled with green on the base; protoconch obscured by coralline growth, whorls 4, flat in outline but heavily ribbed, the body-whorl having twelve ribs which slope forwards from the suture towards the periphery and are crossed almost at right angles by numerous

squamose growth-lines; each rib ends with a flat hollow tooth projecting beyond the periphery; suture only marked by the serrated periphery, as in *A. heliotropium*. A rounded thread runs round the entire shell about one-third above the periphery. The squamose base is slightly rounded, and has six rounded threads between the outside edge and the columella; the second from the outside is very prominent, the fifth is somewhat so, and both persist into the aperture beneath the nacre. Columella white, vertical, the inside rounded and coated with a layer of dull nacre; there is a very slight umbilical depression. Animal and operculum unknown. Height, 10 mm.; breadth, 13 mm.

Hab. Takapuna.

Type in my collection.

N.B.—This shell does not resemble the young of any of our *Astralium*.

Rissoia vulgaris (= common), n. sp. Fig. 3.

Shell pale-horny, imperforate, of 4½ well-rounded deeply sutured whorls, the sutures channelled, protoconch small, shining. The entire shell is longitudinally, finely, diagonally striate. Aperture ovate anteriorly, lip thin, columella vertical, slightly reflexed and continued on the body-whorl by a slight callous line. Height, 2 mm.; breadth, 1¼ mm. Animal and operculum unknown.

Hab. Waipipi.

Type in my collection.

Rissoia micans (= shining), n. sp. Fig. 4.

Shell minute, imperforate, dark rich golden-brown, highly polished; whorls 4, rounded, divided by deep sutures, no sculpture. Columella vertical, arched, dark-brown, slightly reflexed; aperture circular, not continuous, lip simple, very slightly expanded, and semitransparent milk-white in colour. Height, 1¼ mm.; breadth, 1 mm. Animal and operculum unknown.

Hab. Takapuna.

Type in my collection.

Rissoia zosterophila, n. sp. Fig. 5, *a*, *b*.

Shell thin, imperforate, with brightly contrasting colours, the upper half of each whorl milk-white, the lower half dark red-brown; the base is horny, thus leaving the red-brown colour as a sub-peripheral band on the body-whorl; this band forks lengthwise about half a turn from the aperture, on reaching the inner edge of which it stops abruptly in most full-grown specimens. Whorls 6½, scarcely rounded, the smooth elevated protoconch taking up two of these. Periphery bluntly angled, a similar pro-

jection being noticed in the outline near the columella. Aperture angled behind, rounded in front, continuous, thin-edged, the edge slightly expanded. Columella nearly vertical, interior transparent. Operculum quite colourless and presenting a malleated appearance on the internal surface. Since deciding upon describing these shells I have had no opportunity of obtaining the animal alive. Height, 2¼ mm.; breadth, 1 mm.

Hab. Devonport.

This shell is labelled *R. annulata* in the Auckland Museum, but is not that species as named by Professor Hutton.

Rissoia carnosa (= flesh-coloured), n. sp. Fig. 6.

Shell thin, imperforate, flesh-brown, with a cream-coloured band above the periphery, some specimens being a darker brown without the band, others having the last whorl entirely cream-coloured. Whorls 5½ (of which two form the smooth dome-shaped dark protoconch), slightly rounded, the body-whorl more so, and having about twenty straight longitudinal ribs crossed by about twenty-five spiral liræ, which diminish in strength as they ascend to the apex, while the ribs are stronger on the upper whorls and in some specimens die away on the body-whorl. The shell is so thin that the sculpture is plainly visible when looked at through the aperture. Suture well marked; aperture auriform, not thickened anywhere, not continuous. Animal and operculum unknown. Height, 2¼ mm.; breadth, ¾ mm.

Hab. Takapuna.

Type in my collection.

Rissoia candidissima (= very white), n. sp. Fig. 7.

Shell thin, imperforate, semitransparent-white when fresh. Whorls 4½, of which two form the smooth elevated protoconch, very round, with about twelve distant longitudinal ribs on the body-whorl crossed by twelve spiral lirae. Suture deep, aperture rounded but not continuous, slightly thickened. Animal and operculum unknown. Height, 2 mm.; breadth, 1 mm.

Hab. Takapuna.

Type in my collection.

Rissoina (Eatoniella) limbata, Hutt. Fig. 8, *a*.

I give a drawing of the radula × 600 and of the operculum of this species, which was originally described by Professor Hutton as a *Cingula* (the animal being unknown), and then found its way into *Phasianella* (see P. Mal. Soc., iii., p. 8). I also examined the dentition and operculum of transparent-pink and pellucid-white specimens, finding them the same as the type.

Rissoina (Eatoniella) olivacea, Hutt. Fig. 9, *a*.

I examined the radulæ of many typical dark-green and also brown specimens of this shell, further also of the purple-black shells with white sutural band called *R. annulata*, Hutt. I find radula and operculum identical in all. I consider therefore that *R. annulata* intergrades with *R. olivacea*. With Professor Hutton's concurrence I propose for *R. annulata* varietal rank, thus: *Rissoina* (*Eatoniella*) *olivacea*, Hutt. (1882); *Rissoina* (*Eatoniella*) var. *annulata*, Hutt. (1884).

Rissoina agrestis (= clumsy), n. sp. Fig. 10, *a*, *b*.

Shell solid, imperforate, dull, of a purple-brown shading to cream-colour on the body-whorl. Whorls 5½, including a 2½-whorled domed striato-punctate protoconch with a well-defined convex channel at the suture. The three lower whorls are longitudinally, slightly diagonally, rudely ribbed, the channel being ribbed independently. Aperture somewhat angled behind and rounded in front, very thick. Columella vertical, marked by a white shining stripe. Animal unknown. Length, 1½ mm.; breadth, ⅝ mm.

Hab. Takapuna.

Type in my collection.

Very like the illustration of *Rissoa impressa*, Hutt.

Eulimella cœna (= ordinary), n. sp. Fig. 11, *a*.

Shell elongated, slender, white, smooth, imperforate, whorls 7, flat with a blunt heterostrophe apex. Sculpture none, suture slight, aperture ovate anteriorly, columella vertical and slightly twisted. Height, 2½ mm.; breadth, 1 mm. Animal and operculum unknown.

Hab. Takapuna.

Type in my collection.

Corbula pura (= clean), n. sp. Fig. 12, *a*.

Shell white, thin, tinged with pink before and behind the umbones, which are one-third from the posterior rounded end. The fold is sharp, its outline concave, its anterior end being far in advance of the anterior dorsal margin. Prodissoconch quadrate, plain, slightly eroded, the entire shell lightly but clearly and regularly both concentrically and radiately striate, left valve very slightly the larger. Hinge teeth, sinus, and scars, &c., normal. Height, 5 mm.; breadth, 10 mm.; depth from valve to valve, 3 mm.

Hab. Dredged in Rangitoto Channel.

Type in my collection.

Standella aequalis (= uniform), n. sp. Fig. 13, *a*.

Shell a true oval, umbones two-fifths from the anterior end; the entire shell, prodissoconch included, lightly and irregularly concentrically striate. Hinge teeth, sinus, scars, &c., normal. Height, 17 mm.; breadth, 27 mm.; depth of single right valve, 6 mm.

Hab. Kauri Point.

Type in my collection.

Remarks on some Non-marine Shells.

Thaumatodon varicosa, Pfeiffer.

All the shells collected near Waiuku have two teeth, one on the body-whorl and another at the base of the columella margin. This is the case with both adult and juvenile specimens.

Ptycodon pseudoleiodon, Suter.

This shell is found in Waiuku in the adult stage normal and also with combinations, 3 · 1 · 7; 3 · 1 · 10; 3 · 1 · 12, &c.

Phrixgnathus phrynia, Hutton.

This and other shells are found in Waiuku with callous patches indicating the development or loss of throat teeth.

Laoma marina, Hutton.

This occurs (adult) with the throat teeth of *L. nerissa*, Hutton.

Shells to be added to Fauna List.

The following shells in my collection should be added to or reinstated in the list of our fauna :—

Sigaretus undulatus, Hutt. Cape Maria van Diemen.
Ancilla depressa, Sow. Orua Bay.
Terebra venosa, identified by Mr. Suter. Cape Maria van Diemen and Port Waikato.
Pyrgulina rugata, Hutt. Takapuna.
Leuconopsis inermis, Hed. Takapuna.
Pholadidea spathulata, Sow. Narrow Neck.
Venericardia amabilis, Desh. Cape Maria van Diemen.
Venerupis carditoides, Lam. Takapuna.
Philene teres, Hed. Cheltenham Beach, Auckland.

Also the following two shells, which have been omitted from the "Index Faunæ":—

Venus (*Gomphina*) *maorum*, Smith, J., of Mal. 1902, ix., pt. 4.
Unio (*Diplodon*) *websteri*, Simpson, "Nautilus," July, 1902.

ART. XVIII.—*Some Earthworms from the North Island of New Zealand.*

By W. B. BENHAM, D.Sc., M.A., F.Z.S., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 13th September,* 1904.]

Plate XI.

ALL the earthworms, with two exceptions,* that have hitherto been ascribed with certainty to New Zealand have, as a matter of fact, been collected in the South Island, and chiefly from Canterbury and Otago; but during the last year or two I have received numerous specimens from various localities in the North Island, and in the early months of the present year I received from Mr. Elsdon Best a collection of worms made at Ruatahuna, the interest in which is enhanced by the fact that several of the species were in former times used as an article of diet by the Maoris, and are referred to under their Maori names in his article "The Food-products of Tuhoeland" in these Transactions.† I gladly take this opportunity of thanking Mr. Best for his kindness in taking the trouble, at my request, to collect, preserve, and forward to me these extremely interesting species; for not only is this the first occasion in which earthworms have been recorded as being eaten by man of any race, but, from a zoological point of view, they introduce us to a family of earthworms hitherto scarcely represented in New Zealand. To Mr. Charles Cooper, of Auckland, my thanks are also due, for it was at his suggestion that I put myself into communication with Mr. Best, whose article I had not at that time read, and was therefore ignorant of the fact that the Maori esteemed the earthworm as an article of diet. To several other correspondents I herewith offer thanks for forwarding to me specimens, including Captain Hutton, Professor H. B. Kirk, and Mr. H. Suter.

I have already written a detailed account of these new species, and have sent it to the Zoological Society for publication‡; nevertheless it seems desirable to place on record in these Transactions all new species of animals described from New Zealand, even if a certain amount of duplication of articles

* These two exceptions are *Maoridrilus plumbeus* and *Microscolex monticola*, both described by Beddard, from Mount Pirongea, near Auckland.

† Trans. N.Z. Inst., xxxv., p. 45.

‡ Proc. Zool. Soc., 1904.

results. Here and now it is only necessary to present a list of the new species, but I cannot let the opportunity pass by without emphasizing the fact that the predominant earthworms in the North Island belong to a subfamily quite different from that to which the predominant earthworms of the South Island belong, and heretofore believed to be characteristic of New Zealand as a whole.

The South Island earthworms (extending up to and including Stephen Island in Cook Strait) belong to the subfamily *Acanthodrilinæ;* on the other hand, the commonest earthworms in the North Island belong to the subfamily *Megascolecinæ*, which is characteristic of Tasmania and Australia.

The problem of distribution presented to us renders our former ideas on the subject as to the relation of our fauna to that of Australia somewhat confusing: and I do not at present propose to discuss it till I have worked out the line along which the two subfamilies came into contact in New Zealand. I shall be extremely grateful for any earthworms from Nelson and Marlborough, as well as from the southern parts of the North Island, for we are very deficient in knowledge as to the fauna in these parts of the country.

List of New Species.

Fam. MEGASCOLECIDÆ.

Subfam. ACANTHODRILINÆ.

1. **Maoridrilus mauianus**, Benham.
   Loc. Auckland.
   A single individual. Collected by Mr. Suter.

2. **Octochætus michaelseni**, Benham.
   Loc. Wellington.
   A single specimen. Collected by Captain Hutton.

Dinodriloides, Benham (1904).

3. **Dinodriloides beddardi**, Benham.
   Loc. Auckland.
   A single individual. Collected by Mr. Suter.

4. **Rhododrilus edulis**, Benham.
   Loc. Ruatahuna.
   Two individuals. Collected by Mr. Elsdon Best. This worm is known to the natives of Tuhoeland as *tarao* (= *wharu*, and perhaps *huharu*); it appears to be common, and was used as food.*

* I have added diagrams to illustrate the specific characters of this and the following species, for comparison with other species of *Rhododrilus* described in the present volume.

5. **Rhododrilus besti**, Benham.

Loc. Ruatahuna.

A single individual. Collected by Mr. Elsdon Best.

This is the *tokerangi* of the natives, and is not included in Mr. Best's list of edible species. He writes me that it is "found on tracks, &c., in the morning, generally after a wet night."

Subfam. MEGASCOLECINÆ.

TOKEA, Benham (1904).

6. **Tokea esculenta**, Benham.

Loc. Ruatahuna.

Collected by Mr. Elsdon Best, in stony places: it is termed *kurekure* by the natives, who eat it.

7. **Tokea sapida**, Benham.

Loc. Ruatahuna.

Collected by Mr. Best. This is also an edible species, and is not distinguished by the Maori from the preceding species, the same name, *kurekure*, being used for both. It was one of the most prized kinds, and was reserved as food for the chiefs.

8. **Tokea ureweræ**, Benham.

Loc. Ruatahuna.

Collected by Mr. Best. It is the *pokotea* of the Maoris, who included it in their bill-of-fare.

9. **Tokea huttoni**, Benham.

Loc. Whangarei.

One individual. Collected by Captain Hutton.

10. **Tokea suteri**, Benham.

Loc. Auckland.

One individual. Collected by Mr. Suter.

11. **Tokea kirki**, Benham.

Loc. Ohaeawai.

Five specimens. Collected by Professor H. B. Kirk.

12. **Tokea maorica**, Benham.

Loc. Auckland: Waitakerei Bush and Nikau-palm Bush, near Auckland.

Eight individuals. Collected by Mr. Suter.

It will be seen that out of a collection containing twelve new species, only two belong to the predominant genera of the South Island—viz., *Maoridrilus* and *Octochætus*. The genus *Rhododrilus* is represented by one species in the South Island, one species in the Chatham, and two species (described in the present volume) in the southern islands.

The new genus *Dinodriloides* is allied to *Dinodrilus* of the South Island, of which only one species is at present known. There are five species belonging to the subfamily *Acanthodrilinæ*: the remaining seven belong to a new genus, allied to the Cryptodriline series of Australia.

The genus *Tokea* (from the Maori *toke*, an earthworm) is very widely distributed over the North Island, as will be seen from the varied localities at which it has been collected—from Ohaeawai at the north to Ruatahuna in the south-east portion of the island.* It is probably the commonest earthworm in these parts, as two species occur in and around Auckland, three species at Ruatahuna, and from the majority of the other localities no other genus has been received. It is, so far, unknown in the South Island.

To this list of new species from the North Island we must add Beddard's species, *Maoridrilus plumbeus* and *Microscolex monticola*, from Mount Pirongea, described in 1895. But before that date Schmarda described "*Hypogæon orthostichon*," from "Mount Wellington, New Zealand." This worm is now placed, by those who have re-examined the specimen, in the genus *Notoscolex*, a thoroughly characteristic Australian genus; and doubt has been thrown on the accuracy of Schmarda's statement that it was collected in New Zealand—firstly, because no representative of that genus had hitherto been found here, and secondly, because there is no "Mount Wellington" of conspicuous size in New Zealand. It has been suggested that the well-known mountain of that name near Hobart was the real source whence Schmarda obtained the worm, and that the words "New Zealand" were due to a *lapsus calami*†; and I went so far as to refer to it, in a note read before the Australasian Association for the Advancement of Science at Hobart in 1902, as a "neglected Tasmanian earthworm." But these two reasons for doubt may now be laid aside—for, firstly, the genus *Tokea* is closely allied to *Notoscolex*, and the differences are such that unless particular attention were paid to the points of difference they might readily be overlooked, and the description is insufficient to decide the question: it is possible, then, that Schmarda's worm may indeed belong to this new genus *Tokea*. Then, secondly, in reply to a query from me, Professor Kirk informs me that "Mount Wellington is the name of a small volcanic cone just outside Auckland, now under cultivation"; so that the suggestion of a geographical error seems to have

* I have recently received species of this genus from Little Barrier Island.

† Hutton, "Catalogue of the Worms of New Zealand," Trans. N.Z. Inst., xi., footnote, p. 317.

been unnecessary. It is probable that the point will never be decided, and, as Schmarda's worm no longer forms an exception to the zoo-geographical problem, its decision is now of little importance.

EXPLANATION OF PLATE XI.

The illustrations of the anatomy of the earthworms described in this article are purely diagrammatic, indicating only the segmental position of the various organs, the worm being supposed to be slit up along the dorsal line and the body-wall pinned aside.

A group of three diagrams refers to each worm herein described. The left-hand diagram in each of the groups referring to a species represents the external features. The location of the various genital pores is represented as round black dots (if on a papilla this is left white), the clitellum is obliquely shaded, the tubercula pubertatis are vertically shaded.

In addition, the arrangement of the chætæ—labelled *a*, *b*, *c*, *d*—is indicated in segments 5 to 23 on one side; they are omitted on the other side for clearness' sake. The true relative spacing of the chætæ is shown.

The position of the nephridiopores is indicated by the small circles on one side of the figure.

The middle figure represents the alimentary canal and so much of the vascular system as is diagnostic. The latter is black. The gizzard is indicated by vertical shading, the œsophageal glands by more or less horizontal lines. The intestine is not represented as being constricted, which is, however, the case in most worms.

The right-hand figure shows the reproductive system. The gonads are in black. The sperm-sacs are dotted. The sac with penial chætæ when present is indicated, and the muscular duct of the spermiducal gland is transversely striped. The transverse muscles in the 18th segment are shown.

No attempt is made to give the relative sizes of the worms or of the various organs.

ART. XIX.—*On the Oligochæta from the Southern Islands of the New Zealand Region.*

By W. B. BENHAM, D.Sc., M.A. F.Z.S., Corr. M. R. Soc. Tasm., Professor of Biology, University of Otago.

[*Read before the Otago Institute, 13th September,* 1904.]

Plates XII. and XIII.

In the winter of last year (July, 1903) Dr. L. Cockayne paid a visit to the southern islands on the Government steamer "Hinemoa," and while collecting plants was good enough to collect earthworms, which he kindly handed over to me. The following is the list of worms described in the present paper, all but the last being collected during this expedition :—

Fam. MEGASCOLECIDÆ.

Subfam. ACANTHODRILINÆ.

(1.) *Notiodrilus aucklandicus*, Benham.
(2.) *Notiodrilus campbellianus*, n. sp.
(3.) *Rhododrilus cockayni*, n. sp.
(4.) *Rhododrilus leptomerus*, n. sp.

Fam. ENCHYTRÆIDÆ.

(5.) *Marionina antipodum*, n. sp.
(6.) *Enchytræus albidus*, Henle.
(7.) *Lumbricillus macquariensis*, n. sp.

We already know two species of *Notiodrilus* from these southern islands—viz., *N. macquariensis*, Beddard, originally described some years ago, and more recently studied and illustrated by myself,* and *N. aucklandicus*, described by myself in 1902. Hitherto these two worms have been the only Oligochæta recorded from this region, and the other islands have been unexplored for this branch of their fauna. The present contribution thus adds a third species of *Notiodrilus*,† as well as two new species of *Rhododrilus*, which is endemic in New Zealand, and, unlike some of our other genera, is represented alike in the North and South Islands, as well as in the Chathams. The presence, too, of Enchytræids in these southern islands is of interest, as species of both *Marionina* and *Lumbricillus* have been recorded from South Georgia and Tierra del Fuego, while the same species of *Enchytræus* has been met with all over the globe.

The Oligochætal fauna, so far as are known, may here be summarised :—

Antipodes Island :—
Notiodrilus aucklandicus.
Marionina antipodum.

Lord Auckland Isles :—
Notiodrilus aucklandicus.
Rhododrilus cockayni.
Rhododrilus leptomerus.

Campbell Islands :—
Notiodrilus aucklandicus.
N. campbellianus.
Rhododrilus cockayni.
Enchytræus albidus.

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* Trans. N.Z. Inst., 1900 and 1902.

† It may be that these three forms are local varieties of one and the same species.

Macquarie Islands:—
Notiodrilus macquariensis.
Enchytræus albidus.
Lumbricillus macquariensis.

In the present paper I confine myself to detailing the characters of the new species, and will postpone a consideration of the bearing that the facts of geographical distribution have in regard to the previous extension of the New Zealand land surface. I have so much new material waiting investigation that it is desirable to gather together these facts in a general paper at a later date.

Dr. Michaelsen has recently* pointed out that *Notiodrilus kerguelarum* is to be found not only on dry land but also on the sea-shore within reach of the sea-spray, in company with typically littoral Oligochæta such as *Enchytræus albidus*—or, to use his term, it is "euryhaline." It is worthy of note, therefore, that in the collection made by Dr. Cockayne there is further evidence in support of this statement, for in the bottle containing *N. campbellianus* there are *Enchytræus albidus*, a few Polychæta, and a Nemertine. After reading Michaelsen's remarks I wrote to Dr. Cockayne for further details as to the "stations" at which these worms had been obtained, and he writes me that "all the Campbell Island worms were collected near one another on the stony shore of Perseverance Harbour, just above high-water mark. I collected no other worms on Campbell Island. It is possible that sea-spray may reach any place at which the Adam Island worms were collected, but the soil cannot be termed brackish in any degree. As for Ewing Island worms, these were collected on or near the shore. On the other hand, the 'peat bog' in which the worms from Antipodes Island were collected is quite out of the influence of the sea-spray."

Notiodrilus aucklandicus.

The single specimen from the Antipodes Island is, curiously enough, truncated anteriorly, and has lost four anterior segments; this injury, however, is entirely healed up, but no new prostomium has yet been formed, nor have the anterior segments been regenerated, for the porophores, instead of being on segments 17 and 19, occur on the 13th and 15th. Granting this loss of four segments, the organs occupy the normal position.

The colour differs somewhat from the type in being yellowish instead of grey posterior to the clitellum. This is not due to the preservative, for formaline was used in both cases, but is due to colour of intestinal contents.

* Die Geograph. Verbreit. d. Oligochæten, 1903.

The specimen is smaller than the type, being only 55 mm. × 2 mm.

It was collected in "bog land, in peat of *Pleurophyllum*." This "*Pleurophyllum* meadow" is described in detail by Dr. Cockayne in his interesting article "A Botanical Excursion during Midwinter to the Southern Islands of New Zealand"*: "Then the leaves of the past year lie rotting upon the surface of the soil, while their bases form great decayed masses many centimeters in thickness round the leaf-bases of the young leaves of *Pleurophyllum criniferum* or *P. hookeri*. In these sheaths of decaying leaves considerable numbers of earthworms were found, and they appear also to be fairly numerous in the peat itself."

Those from the Campbell Islands were obtained from the "roots of plants" in some number, mature and immature. Their colour is pinkish-brown anteriorly, instead of sienna-brown as in the type. The only noticeable difference anatomically from the type is the absence of definite œsophageal glands, though the gut-wall is thicker and dilated in segments 13, 14, and 15. Also the diverticula of the spermathecæ arise from the duct free from the body-wall.

From Adam Island (one of the Lord Auckland Group) I received nine specimens, of which three are immature. These show no sensible variation in colour.

Notiodrilus campbellianus, n. sp.

Three specimens were obtained, of which two are immature; all are ill-preserved.

Colour (in formaline).—Dark chocolate-brown, with paler clitellum.

Length, 50 mm., approaching *N. macquariensis*.

Prostomium is epilobic, one-third, with a transverse groove.

The *chætæ* are isolated, the interspaces nearly equal, though the gap *bc* (= *aa*) is greater than *ab* or *cd*, and *dd* is considerably greater than *aa*. This chætal formula agrees with that of *N. macquariensis*.

The *clitellum* is complete, extending over segments 13 to 16 in the only mature specimen in my possession.

Genital Pores, &c.—The porophores are white, in line with *b*. There are also paired copulatory tubercles, quite pale in colour, near the anterior margins of segments 17, 19, and 20, in line with *a*; while behind the spermathecal pores in segments 8 and 9 similar tubercles occur in the same line. This, in general, agrees with what I have recorded for *N. aucklandicus*, for in *N. macquariensis* no mention has been made of such tubercles.

Internal Anatomy.—The dorsal vessel is single, and the last

* Trans. N.Z. Inst., 1903, p. 257.

heart is in the 12th segment, as in *N. aucklandicus*. There are no distinct œsophageal glands.

Reproductive System.—The long undulating prostates extend through six and four segments respectively, terminating in segment 22. The duct is thick and muscular, and rather swollen at its entrance to the body-wall.

The penial chæta is rather strongly curved below the tip, as in the allied species, but is more delicate than in either of these. The tip is blunt, as in *N. aucklandicus*, and the ornamentation is in the form of pectinated ridges, as in that species, but are not so close together as in the type, nor do they extend so far towards the tip.

The spermatheca resembles that of *N. macquariensis* in its globular form and two divergent diverticula.

Remarks.—This species is evidently very closely allied to *N. aucklandicus*, yet it differs in several respects from it, and approaches *N. macquariensis* in these points—viz., in its small size, in the spacing of the chætæ, absence of distinct œsophageal glands, form of the spermatheca.

Although I have given a new specific name to this worm, it may become desirable to consider these three forms as varieties of one species.

Hab. Campbell Island. In the bottle containing these specimens were also some *Enchytræus albidus*, Polychæta, and Nemertine. They were all collected near one another close to the sea.

Rhododrilus cockayni, n. sp.

Seven individuals were collected, of which the majority are sexually mature.

Colour.—The general colour is a greyish-purple, darker anteriorly, with brown clitellum. The posterior region is very pale, with a purplish-grey line along the dorsum. The body-wall is thin.

Dimensions.—The specimens have a length of from 100 to 150 mm., with a diameter of 3·5–4 mm. immediately behind the clitellum. The segments number 72 in the shorter and 110 in the larger individuals.

The *prostomium* is epilobic, about one-quarter, without a transverse furrow.

The *chætæ*: *a* and *b* are nearer together than are *c* and *d*, and the formula here is $aa = bc$; $dd = 2cd = 3ab$; or $ab < cd < bc < dd$; while towards the tail *ab* widens out so that the four chætæ on each side are nearly equidistant.

The *clitellum* is saddle-shaped, extending as far downwards as chæta *b*, and covers segments 13–17.

Genital Pores, &c.—The single pair of porophores on the 17th

segment are in line with *ab*, but the male pore is in line with *b*. Copulatory tubercles are variously developed, but in all the mature specimens there are paired oval post-chætal glands on segments 10 and 11 in line with *ab*. Some individuals have others on segment 9 and even on the 8th as well. In a single case, similarly paired papillæ occur on segments 19 and 20 as well as on the two anterior segments, and all are in the same relative position on the segment, and have the same form—viz., transversely oval, with a slight depression—giving the impression of a sucker.

Spermathecal pores: Three pairs, at the anterior margin of segments 7, 8, and 9, in line with *b*. Nephridiopores also in line with *b*.

Internal Anatomy.—The six septa behind segments 8–13 are stout. The dorsal vessel is single; last heart in segment 12. The worm is meganephric.

Alimentary Tract.—A very small gizzard occupies the 5th segment. A large lobulated and highly vascular salivary gland lies on each side of the pharynx. The œsophagus is distinctly dilated in the 13th segment to form a spherical sac, the lining of which has the general villous structure of a gland, though the lateral region is not constricted from the axial œsophagus.

In segments 14–17 the gut is narrow, with a yellowish wall; in the 18th it suddenly dilates to form the thin-walled intestine.

Reproductive System.—Three pairs of sperm-sacs occupy segments 9, 11, and 12. The spermiducal (prostate) glands are long, tubular, and undulating: each extends through the five segments 17 to 21 inclusive. The short muscular duct is confined to segment 17. The sacs of penial chætæ are also long. On the removal of the arcuate muscles from segments 16, 17, and 18, the two sperm-ducts on each side are readily seen on the body-wall, and can be traced backwards outside the prostate duct, where they bend mesially behind it and the penial sac to open to the exterior.

The penial chæta (Plate XIV., fig. 6) is long, delicate, and curved rather abruptly near the tip, which is slightly recurved.

The only "ornamentation" is in the form of a few scattered minute serrated markings some little distance below the tip.

The three pairs of spermathecæ are in segments 7, 8, and 9 (and in one specimen from Adam Island there are three on the left side but four on the right). These increase in size backwards, and the diverticulum becomes relatively longer. Each spermatheca (Plate XIV., fig. 2) consists of a large somewhat ovoid sac with a short wide duct, into which opens a curved cylindrical diverticulum. This, in mature forms, is longer than

the "ampulla," though in the young form and in the anterior sacs it is shorter.

Hab. Campbell Island; Ewing and Adam Islands of the Lord Auckland Group.

Rhododrilus leptomerus, n. sp.

This peculiar species is represented by two mature individuals collected "on moss (? Auckland Islands)."

Colour.—Pale-yellowish, with a white clitellum.

Dimensions.—Length, 75 mm.; breadth, 3 mm; with 82 segments.

Prostomium epilobic, one-half, with a posterior transverse groove.

Chætæ in couples, the individuals of the ventral couple being rather near, the other spaces wide: $aa = bc = cd = 2ab$; $dd = 1\frac{1}{4}aa$.

The *clitellum* is saddle-shaped, and covers segments 13 to 16; it has well-defined margins anteriorly and posteriorly, and appears to be fully developed, as the intersegmental furrows are obliterated except on the ventral surface.

Genital Pores, &c.—A single pair of porophores occurs on the 16th segment in line with chæta *b*: it is only feebly prominent, and on it are three pores, as in other species of the genus—viz., one common to the sperm and prostate ducts, the other two for the two penial chætæ. There are no copulatory tubercles. There is a single pair of spermathecal pores between segments 7 and 8. Nephridiopores in line with chæta *c*.

Internal Anatomy.—There are no thickened septa. The only notes on the vascular system are from longitudinal sections, which show two pairs of hearts, in segments 10 and 11 respectively, of which those in the former segment are especially large. But owing to the hard-coagulated blood in the wall of the gut and blood-vessels the sections were somewhat torn, and I was unable to trace the matter further.

The Alimentary Tract.—There is a short thick-walled gizzard in segment 6, concealed by the muscles of the pharynx. The œsophagus is dilated in segments 12 and 13, but no definite glands are formed. The intestine commences in the 15th segment, where the thick wall of the œsophagus is replaced by a thin wall. The typhlosole is a very low ridge.

Reproductive Organs.—There are two pairs of testes in segments 9 and 10. The three pairs of sperm-sacs are in segments 8, 10, and 11. The first is small and attached to the hinder septum; the others larger and attached to the anterior septa of their segments. All are "botryoidal" and contain developing spermatozoa. The spermiducal gland on each side is very long,

undulating, and bent in a U-shaped fashion. It occupies five segments, 16 to 20 inclusive. The free end of the gland lies in the former segment, and the closely undulating or zigzag portion extends into the 20th, against the hind wall of which it bends sharply on itself, and the rather wider recurved limb passes forwards into the 19th, at the anterior end of which the muscular duct commences. This is narrow and long, passing through three segments to open to the exterior at the 16th segment. The penial sac is also long, occupying the four segments 16 to 19 inclusive.

The penial chæta (Plate XIV., fig. 7) is long, curved, with a spoon-shaped pointed tip, and is without ornamentation. The total length of a penial chæta is 4 mm.

The ovaries are plainly visible in the dissected worm in the 12th segment.

The single pair of spermathecæ lie in the 8th segment. Each (Plate XIV., fig. 3) is a subglobular sac with a short thick duct, which receives a relatively large cylindrical diverticulum which is bent upon itself.

Remarks.—The most remarkable feature about this species is the apparent shifting forwards of the genital organs by one segment—*i.e.*, the genital pore, instead of being on the 17th, is on the 16th segment, and each of the internal genital organs—ovaries, testes, and sperm-sacs—similarly occupy the segment preceding the one normal for the genus. As to the spermatheca in the 8th segment, it is uncertain whether this has been affected, for in *R. edulis* the single spermatheca is in this segment, though in other species with a single pair it is in the 9th.

The position of the male and female gonads is so constant throughout the whole group of earthworms, with the exception of the *Moniligastridæ*, that this forward movement is very puzzling.

Both individuals present this same dislocation. Naturally, this led me to re-examine very carefully the external and internal segmentation, both with a lens of high power and, after bisection and clearing, with the compound microscope, and, further, I cut one individual into a series of longitudinal sections. It at once occurred to me that the prostomium and peristomium might be invaginated, or that an injury had been received at this end; but the latter suggestion was negatived by the occurrence of two individuals presenting precisely the same phenomenon; and, moreover, there is no sign of injury at this anterior end. The prostomium is perfectly well defined; it has the usual relations to the peristomium—it is, indeed, "dovetailed" into the latter segment.

The 1st segment has no chætæ—*i.e.*, it agrees with the usual

character of the peristomium. The chætæ commence in the 2nd segment. This and the following segments are perfectly normal: there is no indication of a double set of chætæ in any of them. There is no furrow in the 1st or 2nd or any subsequent segment to suggest a fusion of two segments; in fact, the segments are not annulated, as is sometimes the case. The worms are fairly soft, not contracted at all, so that the limits of the segments are quite distinct and definite. There seems no possibility of error in the enumeration of the segments such as does occur in a strongly annulated worm (*e.g.*, *Octochætus*). There seems to be no means of explaining the peculiarity from an external examination. Internally, too, the septa, though thin, are quite distinct. There is none of that shifting of septa that occurs in many large worms; and, as the soft condition permitted it to be fully extended, there is no crowding of the septa. Repeated countings, both externally and internally, gave the same result—viz., the ovaries (fortunately large and readily seen) in segment 12, and other organs one segment forward. There is no "spiral segment" such as has been observed by Morgan and others. Longitudinal sections show that the cerebral ganglia occupy the normal position at the hinder part of the 3rd segment; the circumpharyngeal commissure lies in this segment, and the first ventral ganglion occupies the anterior half of the 4th segment, and a single ganglion corresponds to each of the subsequent segments.

The condition of preservation is not sufficiently good to enable me, with certainty, to study the detailed distribution of the ganglion-cells in the first ventral ganglion; but, from a consideration of the facts, the only way to explain the shifting of the organs is to imagine an "excalation" of a segment in front of the testes: if the spermatheca has been unaffected, then the original 9th segment has disappeared; or if the spermatheca has been moved forwards, then one segment lying between the 2nd and 8th has disappeared; but as the gizzard is in the 6th segment the former suggestion is the more probable. If we had had only a single individual this peculiar forward shift would have been remarkable enough, and might have been explained by supposing that the anterior extremity had been cut off, and that an imperfect regeneration of segments had followed—a regeneration in which one segment short of the full number had been formed; but when two individuals exhibit exactly the same phenomenon it does not seem possible to refer it to regeneration. Nevertheless, I do not consider it necessary to form a new genus for the reception of the worm—as we should have done a few years back—for in all essential structural points it agrees so closely with species of *Rhododrilus* that it must be looked upon

as an extremely abnormal species of that genus: though it is true that in no other species is the spermiducal gland provided with such a long muscular duct.

Marionina antipodum, n. sp.

Four small Enchytræids appear to belong to this new species. The longest is 11 mm. in length and 0·75 mm. broad, with 35 segments.

The chætæ are very feebly sigmoid, the points being slightly curved: there are nearly constantly four in each bundle throughout the body, only in a few anterior segments are there five in each bundle.

The clitellum is girdle-like, completely covering segments 12 and 13.

The usual head-pore was noted.

The œsophagus passes gradually into the intestine, being, however, rather dilated in segments 8, 9, and 10.

There are four pairs of septal glands, lying in segments 4, 5, 6, and 7.

The dorsal blood-vessel commences at the hinder end of the 13th segment, and immediately in front of its origin it becomes a good deal dilated, but no "cardiac body" is present. The blood was in life apparently colourless, as the blood-vessels, instead of being filled with a red-stained or yellowish coagulum, are empty. In an entire specimen (stained) I was unable to detect the vessels; but in transverse sections the dorsal vessel appears as a small empty tube with a single nucleus on either side; while even anteriorly the ventral vessel appears to be closely adherent to the œsophageal wall.

The segments 10 and 11 are filled with spermatozoa, and the septum 11/12 is pushed back to the end of the 13th segment.

The testes are quite small and relatively loose in structure, though there are no definite lobes, the edge being slightly frayed.

The sperm-funnel is a good deal curved in the entire specimen, but appears to be about four times as long as its breadth. The penial apparatus (Plate XIV., fig. 9) is comparatively small, as it scarcely exceeds the thickness of the longitudinal muscles of the body-wall. Opening into it, however, is a conspicuous prostate gland.

The spermatheca (Plate XIV., fig. 10) is a long pyriform organ, in which the muscular duct is not distinctly marked off from the sac, which, moreover, is empty in all the individuals examined. The duct is without glands, but at the pore is a couple of groups of gland-cells—one anterior and one posterior.

It should be noted that the longitudinal muscles, instead of

consisting of a single row of fibres, present several layers, as Ude has noted in *Lumbricillus verrucosus*.

Loc. Antipodes Island.

Remarks.—I cannot fit this worm to any of the species diagnosed in Michaelsen's monograph.* It does not agree with any of the South American forms described by Ude;† for, amongst other differences, I do not find any "subneural glands" in the present worm, although the specimens sectioned are sexually mature.

Enchytræus albidus, Henle.

Specimens indistinguishable from this widely distributed species were collected on Campbell Island, close to the sea; and I have specimens from Macquarie Island, which were collected some years ago. I may add that a re-examination of the worm collected and named *E. simulans* by me‡ convinces me that this name must be eliminated: they are *E. albidus*, as I at first imagined them to be.

Lumbricillus macquariensis, n. sp.

Several specimens of this Enchytræid were collected some years ago by Mr. Hamilton on Macquarie Island, and are entered in the Museum register by the late Professor Parker as "small Oligochæta from brackish pools, with *Siphonaria*, planarians, &c." I take this opportunity of giving an account of this species.

Length, 23 mm.; breadth, 1·25 mm.; with 60 segments.

Chætæ very feebly sigmoid and relatively small, in the usual four bundles of 4–7 per bundle. Anteriorly there are in several segments six dorsal and four ventral, while in the 2nd segment six dorsal and seven ventral. Posteriorly the usual numbers are four or five dorsal and six or seven ventral. There are no ventrals in segment 12, and the dorsals are few in the 12th and 13th segments.

The clitellum covers segment 12 and part of the 13th, ceasing at the level of the chætæ. The male pore, in 12, is in some cases prominent owing to the protrusion of the terminal organ.

The usual head-pore is present between the prostomium and the 1st segment. The œsophagus passes very gradually into the intestine, which commences in the 15th segment. There are three pairs of septal glands, as usual.

The dorsal blood-vessel arises either at the hinder end of the

* Michaelsen, "Das Tierreich: Oligochæten," 1900.
† Ude, "Enchytraeiden," in Hamb. Magalhaen. Sammelr., 1896.
‡ P.Z.S., 1903, vol. ii., p. 219.

13th or at the commencement of the 14th segment. The blood appears to have been reddish in life.

In segments 10 and 11 there are great lobulated masses attached to the body-wall at the insertion of the septum 10/11, some lobes passing forwards and even reaching into the 9th segment, others backwards. This is the "multiple testis" (of Claparede); but, as Michaelsen has shown, it is only "testis" at its base—towards the extremities of the lobes the sperm mother cells are found dividing up, and various stages in sperm-formation occur.

The tub-shaped sperm-funnel (Plate XIV., fig. 13) in the 11th segment has a length equal to about twice its breadth. The narrow sperm-duct coils considerably immediately after passing through the septum 11/12, then takes a straight course to the "penis." This consists of a spherical mass of gland-cells enclosed in a thin muscular coat, consisting of circular and longitudinal muscles. Some of the gland-cells open directly to the exterior, others into the sperm-duct as it passes through the apparatus. The sperm-duct arrives at the outer side of the "penis," which it perforates obliquely to open externally at its centre. The area of the body-wall over which the gland-cells open is, in the specimen sectionised, retracted, so that a deep narrow pit results.

The ovary, like the testis, is "multiple"—*i.e.*, lobulated—each lobe being moniliform, consisting of strings of ova, while a few large ova lie free in segment 13.

The oviducal pore is visible on the mounted specimen at the junction of segments 12/13.

The spermatheca has the usual position, opening, that is to say, between segments 4/5. It (Plate XIV., figs. 11, 12) is a cylindrical tub-shaped sac, with a sharply constricted, very short duct which is surrounded by a circle of gland-cells. At the opposite end of the sac a narrow tube puts it into communication with the œsophagus.

The nephridia have a small pre-septal portion, and a large post-septal region whence the duct passes from the hinder end to the body-wall, usually bending forward below the rest of the organ.

There are three subneural (? copulatory) glands—two large ones in segments 14 and 15, and a smaller one in the 16th segment.

In transverse section it is seen that the gland (Plate XIV., fig. 8) rises up the sides of the nerve-cord and leaves the greater part of its upper surface uncovered. Each lobe is of considerable size—at least four or five times the diameter of the nerve-cord—and extends laterally as far as the ventral chætæ. The ducts —*i.e.*, necks—of the gland-cells pass through the circular mus-

cular coat of the body-wall, and spread out fan-wise below the epidermis.

Remarks.—This species appears to be nearly allied to *L. maritimus*, Ude,* from which, however, it differs in the following points: It is more than twice the length, and contains nearly twice as many segments; the excess of chætæ in the dorsal bundle of some of the anterior segments, and the fewer chætæ in the bundle of the hinder segments; the less extent of the clitellum; the relatively smaller size of the sperm-funnel, which in *L. maritimus* is three or four times longer than broad (the form of the spermatheca appears to differ, for Ude makes no mention of the narrow œsophageal duct, saying that the "beutelformige" sac communicates by its narrow end with the gut); the relatively great size of the subneural glands in the present species; and the presence of a third small one in the 16th segment.

EXPLANATION OF PLATE XIV.

Fig. 1. A spermatheca of *Rhododrilus kermadecensis.*

Fig. 2. A spermatheca of *Rh. cockayni.*

Fig. 3. A spermatheca of *Rh. leptomerus.*

Fig. 4. Penial chæta of *Rh. kermadecensis*, seen from above (×350).

Fig. 5. The same, side view, showing spoon-like tip (×350).

Fig. 6. Penial chæta of *Rh. cockayni* (×350).

Fig. 7. Penial chæta of *Rh. leptomerus* (×350).

Fig. 8. *Lumbricillus macquariensis.* A transverse section of a subneural gland (camera×175). *a*, nerve-cord; *c*, circular muscular coat; *e*, epidermis; *l*, longitudinal muscular coat.

Fig. 9. *Marionina antipodum.* The aperture of the sperm-duct, from a transverse section (×175, camera). *d*, sperm-duct; *gl*, spermiducal gland, opening into terminal apparatus; *p*, pore; *l*, longitudinal coat of muscles consisting of several fibres in depth.

Fig. 10. *Marionina antipodum.* The spermatheca. *gl*, gland at its exit; *a*, œsophageal opening; *p*, external pore.

Fig. 11. *Lumbricillus macquariensis.* A spermatheca, with rosette of glands at the pore. *o*, œsophageal opening.

Fig. 12. The same. Base of spermatheca (from a transverse section), showing very short muscular duct, and the glands around the pore.

Fig. 13. The same. The male apparatus for an entire individual. *d*, duct; *f*, funnel; *p*, pore; *s*, septum.

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* Ude, "Enchytraeiden," Hamb. Magalhaen, Sammelr., 1896, p. 6.

Art. XX.—*Earthworms from the Kermadecs.*

By W. B. Benham, D.Sc., M.A., F.Z.S., &c., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 8th November,* 1904.]

Plates XIII. and XIV.

Owing to the thoughtfulness of Mr. R. Shakespear, of Little Barrier Island, I am indebted to Captain Bollons, of the Government steamer "Hinemoa," for the first samples of the Oligochæta that have been collected in the Kermadecs. Captain Bollons was good enough to take a considerable amount of trouble to obtain these worms. The soil forms, he tells me, a very thin covering of decayed vegetation upon pumice rock, and he was unsuccessful in his earlier efforts to find any earthworms, but finally, at Coral Bay, his persistency was rewarded. My best thanks are due to these gentlemen for their kindness.

I received the specimens alive, packed with soil and moss in a tin box: they consisted of three small earthworms and six Enchytræids. Of the earthworms, two were immature individuals of some species of the genus *Allolobophora* belonging to the family Lumbricidæ—the members of which are readily transported, and are, as a matter of fact, widely distributed by the agency of man. Though I am unable to identify the species to which these individuals belong, there can be little doubt but that they have been "introduced" by some means, though Captain Bollons states that this part of the island has never been inhabited; nevertheless, some parts have been occupied, and there can be no difficulty in explaining the presence of these worms here. The third worm is mature, and belongs to the genus *Rhododrilus*,* which, according to Michaelsen's most recent writings, has its headquarters in New Zealand, and is represented on both the main islands as well as on the outlying islands. The present species, however, differs from any hitherto described, and I propose to name it

Rhododrilus kermadecensis, n. sp.

Colour.—Pinkish, with transparent body-wall.

Dimensions.—Length, 65 mm.; diameter, 1·75 mm.; with 108 segments.

Chætæ.—The eight bristles are wide apart, and approximately their arrangement in the midbody is $ab = \frac{1}{2}bc$; $bc = cd = 2ab$; $aa = bc$; $dd = 2cd$. But at about the 20th segment the lines

* It appears from a recent work by Michaelsen that he would fuse the species of *Rhododrilus* with those of *Microscolex*, the older genus. I have given reasons in a paper forwarded to the Zoological Society for distinguishing the two genera.

of *c* and *d* descend slightly, so that the gap *bc* is reduced, and *dd* increased, in the forepart of the body.

Prostomium epilobic, about one-half, without a posterior transverse groove.

Clitellum covers segments 13–18 inclusive. The ventral chætæ and intersegmental furrows are visible, though the skin is somewhat thickened across the ventral surface.

Genital Pores, &c.—A pair of large porophores on the 17th segment, in line with chætæ *ab*; and in front of the chætæ there is a single large median "copulatory tubercle," in the form of an oval glandular pad, not very prominent, covering the whole of the ventral surface of segment 19, and the prechætal region of the 20th.

Dorsal pores are visible posteriorly.

Internal Anatomy.—In the bisected individual I made out the following points, sufficient to characterize the species: The dorsal blood-vessel is enlarged in segments 14, 15, and 16; the last hearts are in the 13th segment. The gizzard is quite minute, in segment 5. There is no œsophageal gland, though the tube is dilated in the 13th and 14th segments. The intestine commences in the 18th.

The Reproductive System.—The sperm-sacs lie in segments 9, 11, and 12. The prostate is a large, tongue-shaped gland, extending through the six segments 17–22, with a short muscular duct in the 17th. A couple of long chætal sacs underlie the prostate, extending back from the 17th to the 21st segment. Each sac contains three chætæ—a functional "penial chæta" and two smaller ones at different stages of development. The penial chæta (Plate XIV., figs. 4, 5) is long, delicate, and bent distally. The tip is curved, spoon-shaped, so that the side and top views differ. The surface is quite devoid of ornamentation.

There are three pairs of spermathecæ, in the segments 7, 8, and 9. Each (Plate XIV., fig. 1) is an ovoid sac, with a short muscular duct about half the diameter of the sac. It receives close to the body-wall a long cylindrical diverticulum, which in the specimen studied is curved in an S-shaped manner. The tip is not dilated (till compressed), but the base is enlarged at its union with the duct.

Remarks.—In the possession of three pairs of spermathecæ this species resembles *R. cockayni* from Campbell Island, from which, however, it differs in its colour, dimensions, arrangement of copulatory tubercle, and form of penial chæta.

Art. XXI. — *Note on the Occurrence of the Foraminiferan Genus* Ramulina *in the New Zealand Waters.*

By W. B. Benham, D.Sc., M.A., F.Z.S., &c., Professor of Biology, University of Otago.

[*Read before the Otago Institute, 13th September,* 1904.]

During a dredging excursion in the summer of 1904, in which Mr. Charles Hedley, of the Australian Museum, Messrs. Suter, Cooper, Park, Murdoch, and others, took part, several interesting animals were obtained at a depth of about 100 fathoms, and amongst them the peculiar glassy foraminifer *Ramulina globulifera*. This has been described from the New Zealand waters by Brady, in the "Report of the 'Challenger' Expedition" (vol. ix.), but as it has escaped the notice of Mr. Hamilton, who drew up the admirable abstract from the "Summary," and published by the New Zealand Institute under the title of "Deep-sea Fauna of New Zealand," and as it is not enumerated in the "Index Faunæ Novæ-Zealandiæ," it seems desirable to place on record its occurrences within the New Zealand area.

The specimens which were handed to me by Mr. Hamilton for identification were obtained at a depth of 110 fathoms, east of Great Barrier Island, lat. 36° 8′ S., long. 175° 55′ E.

The following is quoted from Brady (*loc. cit.*, p. 587):—

"Fam. Lagenidæ.

"Subfam. Ramulinæ.

"Test branching, composed of spherical or pyriform chambers, connected by long stoloniferous tubes.

"*Ramulina*, Rupert Jones (1875).

"Test free, branching; consisting of a calcareous tube swollen at intervals so as to form more or less definite, often irregular, segments, from which lateral stolons or branches are given off. Texture hyaline."

R. globulifera, Brady (1869) was obtained by the "Challenger" off the west coast of New Zealand in 145 and 275 fathoms (the latter was at station 166).

It has been met with on various stations in the Pacific, and also in the North Atlantic.

Figures of the species are given on pl. lxxvi, figs. 22–28, of vol. ix., "Challenger" Reports.

ART. XXII.—*Further Notes on the Sipunculids of New Zealand.*

By W. B. BENHAM, D.Sc., M.A., F.Z.S., &c., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 8th November,* 1904.]

Plates XV. and XVI.

DURING the present year I have received specimens of two new species of Sipunculids, each representing a distinct genus not hitherto recorded from our coastal waters; and, in the absence of the requisite literature whereby to compare these with species described from elsewhere, I propose to give new names to them for the purpose, at any rate, of reference.

PHASCOLOSOMA,* Leuckart.

P. novæ-zealandiæ, n. sp.

A specimen was removed from the stomach of the dog-fish *Mustelus antarcticus*, which was being dissected in the Biological Laboratory.† The Sipunculid was partly macerated, but not so much as to prevent a study of its anatomy, sufficient, I believe, to characterize it.

The body-wall had been torn (by the shark's teeth, perhaps), and the skin had separated from the muscular coats, which, together with the viscera, protruded through the rupture.

Colour.—The skin is pale-yellowish; the posterior end and the introvert are pale-brown, probably darker in life.

Dimensions.—The total length of the skin is 310 mm., of which the introvert measures 75 mm.; the diameter of the body was about 10 mm.; and the base of the introvert about 4 mm. (Plate XV., fig. 1). These measurements are only approximate: in the first place the skin was softened and undoubtedly more extended than if it had been preserved in the usual manner; again, the skin was flattened so that the diameter had to be estimated.

General Description.

The skin is rough, with small brown tubercles and papillæ scattered more or less uniformly over the whole body and introvert (Plate XVI., fig. 8); but they are rather more densely arranged in the latter region, and also at the hinder end of the

* See my article in vol. xxxvi. of the Trans. N.Z. Inst., p. 172. The worm named by Hutton *Phascolosoma annulatum* belongs to the genus *Physcosoma*, as defined by Selenka.

† At the same time and from the same viscus a species of *Echiurus* was found which differs from *E. novæ-zealandiæ*, Dendy, in having two circles of hooks at the hinder end; but its internal organs were absent, so that no means of identification were to hand.

body. Here, too, the skin is wrinkled, forming irregular circular and a few obscure longitudinal ridges.

Each papilla as seen when the skin is examined under the microscope (Plate XVI., fig. 9) is somewhat ovoid in elevation, with a narrowed base of attachment; it is circular in plan, and about $\frac{1}{10}$ mm. in diameter. It appears as a thick brown ring with a central light area. Further investigation by means of section shows that the epidermis has macerated away, and that these papillæ are entirely dermal, with a wall of connective tissue; and probably, in well-preserved material, this clear centre will not be visible (Plate XVI., fig. 10). In my sections the axial canal communicates with the subdermal spaces, and is traversed by what I take to be a nerve, which breaks up just before reaching the apex of the papilla into fine fibrils which are less stained than the nerve itself. Possibly, however, this axial thread is the remains of some secretion from gland-cells which have been destroyed (*cf.* Shipley's figure of the skin of *Onchnesoma*, pl. ix., fig. 6, Quart. Journ. Micr. Sci., xxxiii.). But it is unnecessary to discuss this matter here.

The tentacular crown was invaginated, so that the muscular wall of the introvert had to be slit open in order to ascertain the arrangement. There are numerous simple filiform tentacles springing from an undulating line of origin; and corresponding with four of these undulations are four well-marked thickenings or ridges along the œsophageal wall, of which two lie on each side, leaving a gap dorsally and ventrally. By pushing forward the wall of the œsophagus so as to cause the tentacles to occupy their proper position when fully extended, I have, as a result of the study of this preparation, been able to make a drawing of what is probably their appearance in life (Plate XV., fig. 2).

Internally, I was only able to note the following facts: The longitudinal muscles form a continuous sheet. There are two retractor muscles only, attached to the body-wall pretty far forward (my measurement gives 70 mm. below the tentacular crown: this was taken along the muscular wall, which, as above stated, was separated from the skin, hence the discrepancy between this statement and the "length of introvert").

The alimentary canal still contains mud, and its wall is pretty firm, but had been thrown into a good deal of disorder by being ejected through the rupture in the body-wall—hence I can give no satisfactory account of its coils. Notwithstanding a certain degree of digestion to which the animal had been submitted, the dorsal blood-vessel still retains an orange-brown tint, and can be traced up to the base of the tentacles and along the dorsal ridge.

Remarks.—The only species with which I have been able

to institute any detailed comparison is the antarctic form, *P. capsiforme*, Baird,* and the varieties described by Michaelsen.† From this species it differs in several important respects, and is quite distinct from it.

SIPUNCULUS, Linnæus.

S. maoricus, n. sp.

Two individuals were forwarded to me by Mr. Suter. They were found washed up on the beach at Tauroa Point, Ahipara, near Cape Maria Van Diemen. They had apparently dried up to some extent before being preserved, as the skin is tough and hard, and the internal organs are not sufficiently well preserved to be described.

Colour.—Pale-yellowish; perhaps somewhat translucent when alive.

Dimensions (Plate XV., fig. 3).—Total length, 116 mm., of which the introvert occupies 12 mm.; the diameter of the body at about the middle is 10 mm., and the base of the introvert measures 4 mm.‡ The anus lies 6 mm. below the base of the introvert. Thus the length is about 11½ times the breadth, and the introvert is about one-ninth of the total length.

General Description.

The body is, as always in this genus, marked with distinct circular and longitudinal furrows, dividing the surface into a number of rectangular areas (Plate XVI., fig. 13); the circular furrows and ridges being more conspicuous in that part of the body which is contracted, the longitudinal ones where it is less contracted. The hinder end of the body is slightly pointed, and here the longitudinal ridges are most conspicuous, converging to the mammilla-like tip.

The introvert, which is partly retracted in both specimens, is for the greater part of its extent covered with recurved hook-like tubercles, which are white (Plate XVI., fig. 11). These are not arranged in any very definite manner, though partly they form oblique rows. The tubercles are rather larger dorsally than ventrally, and also diminish slightly in size as the tentacles are approached, at the same time becoming softer. Between the tentacular crown and the tubercles is a naked area about 2 mm. or 3 mm. in extent (Plate XVI., fig. 7). Each of the hook-shaped tubercles§ has an irregularly rounded but wrinkled apex. It is

* Fischer, "Gephyreen," Hamburg. Magalhaen. Sammelr., 1896.

† Michaelsen, "Die Gephyr. v. Sud-Georgien." Jahrb. Hamburg. Wiss. Anstalt vi., 1889.

‡ In inches this is about 4½ in length by ⅛ in diameter.

§ The word "papilla" has been used for glands immersed in the body-wall; otherwise it would seem a more suitable word to use in the present connection.

covered by cuticle, which is thicker on the external convex surface than on the apex or inner face; below this are several "bicellular glands," which project downwards from the epidermis into the dermis or fibrillated connective tissue (Plate XVI., fig. 12). The latter is excavated by a great space which at the base of the tubercle is in free communication, by means of a small aperture, with the general body cavity. In this space is a mass of spherical cells, each with a refringent body and a deeply staining nucleus. At first I took this for a specialised group of connective tissue-cells, serving as a skeletal axis to the tubercle; but examination of serial sections shows that this mass of cells is continuous with masses of granular cœlomic cells adhering to the body-wall, and in some cases the transition between the two appearances—refringent and granular—can be made out. Unfortunately, the material is not sufficiently well preserved to enable me to describe in greater detail this structure; but it appears to serve as a means of erecting these tubercles, for when the strong muscles of the body-wall contract this cœlomic fluid will be driven into these subdermal spaces.

On the body-wall itself, as opposed to the wall of the introvert, there are no tubercles: the usual lymph-spaces alternate with groups of bicellular glands, as has been described by previous writers on the histology of *Sipunculus*.

As the tentacular crown was invaginated, it is not altogether easy to reconstruct the appearance which it has when fully extended. On slitting open the œsophagus, five ridges, covered with tentacles, are seen (Plate XV., fig. 5): of these one is dorsal, two are lateral, and two latero-ventral; the dorsal ridge is the largest, and bears more numerous tentacles. The tentacles themselves are flattened, membranous, and truncated distally—quite unlike the more or less cylindrical tentacles of *Phascolosoma* and other genera; and it has been shown by various authors that in the genus *Sipunculus* the tentacles are really the jagged edge of a membrane: various species show different degrees in which the margin of the circumoral membrane is cut into, so that in some the "tentacles" are short and in others longer. In the present species the membrane is almost entirely "frayed" out into these tentacles. By artificially pushing the œsophagus and crown upwards we may cause the crown to assume, to some degree, the condition of eversion; and from a study of such a preparation, and of the ridges themselves, I venture to "reconstruct" this tentacular crown (Plate XV., fig. 4), which is very unlike that of the species of *Sipunculus* usually figured; but from the brief diagnosis of "*Phallosoma*," Levinsen, given by Yves Delage and Herouard,* there seems to be some resemblance

* Traité de Zool. Concréte, v., p. 21.

to the tentacular arrangement of that arctic form. Again, in the same text-book, a form named *Stephanostoma* by Danielssen and Koren is stated to have "six great groups of tentacles"; but this form is regarded by Selenka as a *Phascolosoma* and not a *Sipunculus*.

The appearance, then, of this tentacular crown will be, when fully everted, very different from that of either *Dendrostoma* or *Physcosoma*.

Internal Anatomy.—The longitudinal muscular coat consists of about twenty-seven distinct bands in the middle of the body: these run independently for considerable distances—*i.e.*, anastomoses are very infrequent; necessarily they become more frequent posteriorly, where the number of bands decreases.

There are four retractors, all of the same length, arising from the body-wall about 20 mm. below the base of the introvert. The dorsal retractors arise from four longitudinal muscle-bands, and the ventrals from three of them.

The intestine, filled with sand, has such a thin wall—probably due to *post mortem* changes—that it was impossible to trace the coils, or to detect the extent of the spindle muscle, for the wall burst on the slightest touch. The coils were attached to the body-wall by numerous delicate threads. The rectum runs close to the body-wall for a distance of 8 mm., and appears to be adherent thereto.

I was unable to detect any posterior cœca, nor were the nephridia preserved.

Remarks.—I have given a new name to this *Sipunculus*, as it does not agree with the descriptions of any species in the small collection of literature available. Unfortunately I have not access to Selenka's monograph, so that it is possible that this article is a work of supererogation. Judging by the reference to the hook-like tubercles of *S. australis*, I expected that it would belong to this species; but the figure and description given by Shipley* do not seem to bear out this idea: it is true neither figure nor description is very detailed, but they are sufficient to indicate general differences. His account says nothing of the great axial cavity of the tubercle, and his figure shows gland and tubercle as distinct things (pl. xviii., fig. 5); and the brief diagnosis given by Quatrefages† does not incline one to refer my specimen to that species. The same negative result follows a comparison of the diagnoses of other Australian species given by the latter author.

* Willey's Zool. Results: Report on *Sipunculoidea*.

† Hist. Nat. des Annelés, ii., p. 619.

Note on Dendrostoma.

D. huttoni, n. sp.

In my previous article (Trans. N.Z. Inst., xxxvi., p. 180) I spent some time in trying to demonstrate the probability that *Sipunculus lutulentus*, Hutton, is a synonym of *S. æneus*, Baird, and proceeded to state that I believed the species of *Dendrostoma* that I was describing was identical with the latter. I am now of opinion that I was altogether too precipitate in my conclusions. Some of the reasons that led me, at that time, to formulate these conclusions were: (1.) Two genera of Sipunculids, and only two, had been collected in recent times on our shores, and these at various spots from Auckland Harbour to Stewart Island. (2.) Both these had been described, so far as external features are concerned, and had been named, by Captain Hutton. (3.) In this Museum were certain tubes containing examples of two forms, with Hutton's labels upon them: one of them is undoubtedly the type of *Physcosoma annulatum*; the other I had reasons to think might be the type of his *Sipunculus lutulentus*. (4.) The latter, however, I found to belong to the genus *Dendrostoma*.

The proper proceeding would have been to have named this species *Dendrostoma lutulenta*, Hutton; but I went further, and, concluding that Hutton's species was identical with Baird's, gave it the name of *D. æneum*.

Now, there are two very important lacunæ in the evidence for this procedure: Firstly, we have no knowledge whatever, from the brief account of the external anatomy given by Baird, of the generic status of "*S. æneus*." Secondly, we are by no means certain that the specimen alluded to as coming from Cape Campbell is Hutton's type of "*S. lutulentus*"; for, although Captain Hutton wrote me that, so far as he remembered, he had only one specimen of this species and that came from Cape Campbell, yet the individual is *less than half the size* of *S. lutulentus* as described by him. That ought to have put me on my guard against identifying the *Dendrostoma* with Hutton's species.

Now, in his original account of *P. annulatum* Hutton states that he had obtained specimens from Dunedin and Cape Campbell: the former is in the Museum, as I stated in my article, fully labelled by Hutton; but I cannot find any specimen of this species with the latter locality attached. It has occurred to me that possibly this specimen referred to as "*b*" in my article was mistaken by Hutton for an individual of *P. annulatum*: it is true it differs in various ways from that species, even externally, but in size and general form it is more like it than like his description of *S. lutulentus*. At any rate, I ought to have

been contented with the suggestion merely of the identity of the *Dendrostoma* with Hutton's *S. lutulentus*. But since writing that article I have received representatives of two more genera, and this leads me to doubt whether even this suggestion is probable. We must bear in mind that at the time Captain Hutton wrote the limitations of the genera of Sipunculids were by no means so clearly recognised as at the present day; and it is not quite certain to what genus Hutton's species belongs.

I propose, then, to name the *Dendrostoma* after our leading naturalist in New Zealand, so that it will now stand as *Dendrostoma huttoni*, Benham = *Phascolosoma huttoni*, Benham (Index F.N.Z.) = *Dendrostoma æneum*, Baird (Benham, Trans. N.Z. Inst., xxxvi., p. 177).

Both Baird's and Hutton's species of *Sipunculus* must stand amongst our "species inquirendæ." I much regret the confusion to which my former article will perhaps give rise.

The figure (pl. vii., fig. 12) illustrating my account* of the tentacular crown of *Dendrostoma huttoni* does not do justice to the elegance of this organ: the lobes are too broad and the tentacles too short. I have therefore drawn another figure from a fully extended specimen, which is reproduced on Plate XV., fig. 6, for comparison with the corresponding organ of the genera described in the present communication.

EXPLANATION OF PLATES XV. and XVI.

Fig. 1. *Phascolosoma novæ-zealandiæ:* half natural size.
Fig. 2. The tentacular crown of the same: oral view; magnified; reconstructed.
Fig. 3. *Sipunculus maoricus:* natural size. *a*, the partially retracted introvert; *b*, contracted region of the body, where the circular ridges are very distinct.
Fig. 4. Tentacular crown of the same: oral view; magnified; reconstructed.
Fig. 5. One of the latero-dorsal ridges of the tentacular crown of the same, as seen on the wall of the opened introvert: stained and mounted; the arrow indicates the anterior end of the body; (camera, magnified).
Fig. 6. *Dendrostoma huttoni:* oral view of tentacular crown; magnified.
Fig. 7. *Sipunculus maoricus:* side view of the anterior end of the introvert; magnified. *a*, tuberculated region; *b*, smooth region.
Fig. 8. *Phascolosoma novæ-zealandiæ:* a piece of skin from the body-wall, as seen through a hand-lens, showing the characteristic papillæ (*p*).
Fig. 9. The same: a papilla much enlarged.
Fig. 10. The same: a papilla in longitudinal section (camera × 80). *ax*, axial canal; *ct*, dermis; *pg*, pigment granules of the outer part of the dermis (the epidermis had macerated off); *x*, cord of granular material in the axial canal (? nerve or secretion).

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* Trans. N.Z. Inst., xxxvi., p. 177.

Fig. 11. *Sipunculus maoricus:* piece of the wall of the introvert (seen under a low power), showing the hook-shaped tubercles; with (*a*) an axial mass of cells.

Fig. 12. The same: a tubercle in longitudinal section (× 80). *a*, axial mass of cells, in continuity with—*c*, a group of cœlomic corpuscles; *cm*, circular muscles of body-wall; *d*, dermis; *gl*, epidermal glands; *lm*, longitudinal muscles.

Fig. 13. The same: a portion of surface of body (as seen through a hand-lens) showing the characteristic longitudinal and circular grooves marking out raised rectangular areas.

Art. XXIII.—*The Aquatic Larva of the Fly* Ephydra.

By W. B. Benham, D.Sc., M.A., F.Z.S., &c., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 9th August*, 1904.]

Plate XVII.

Amongst the organisms collected by Mr. J. A. Thomson in a saline pool at Barewood, Central Otago, which were submitted to me for identification by Mr. G. M. Thomson, were a number of small brown larvæ, or rather "puparia," having rather a peculiar form. This larva, which for reasons stated below I ascribe to the Dipteron genus *Ephydra*, resembles in general form and structure the "rat-tailed" larva of the hover-flies (*Helophilus** and *Eristalis*†)—in the very reduced condition of the head, in possessing a series of paired groups of claw-shaped spines segmentally arranged along the ventral surface, and in the long posterior respiratory tube or "tail"; but in the two genera just named this tube is retractile, whereas in the insect herein described it is not retractile, and is, moreover, bifurcated.

In looking through the small amount of general literature on the *Diptera* available here, the only genus of flies that I was able to find in which the larva of this general form of structure has a bifurcated respiratory tube is *Ephydra*. No doubt a figure of this larva is to be found in one or more recent monographs, or in memoirs published in periodicals concerned with entomology; nevertheless, in the interests of those who are unable to consult these works, it seems to me worth while to present a brief illustrated account, so that naturalists in New Zealand may be able to identify the creature. My identification rests upon the brief accounts contained in Westwood's "Introduction to the Modern Classification of Insects" (1840), and in Packard's "Guide to the Study of Insects" (1872). The former author

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* Hudson, N.Z. Entomology, p. 58, pl. vii., fig. 1.

† Miall's Nat. Hist. Aquatic Insects, p. 198 *et seq.*

gives a poor figure (vol. ii., p. 569, group 132, fig. 11) which shows the bifurcated tail, following ten claw-bearing segments. He states (p. 574), "Many species of *Ephydra* frequent salt marshy situations. The larva is cylindrical, without feet, and the terminal segment of the body very long, and terminated by a long fork, the prongs of which support spiracles at the tip; the puparium scarcely differs from the larva." Packard, on p. 414, also represents, in a slightly more detailed figure, the "puparium" of another species. I find no reference to the genus in Miall's interesting book, nor in the Cambridge Natural History.

Description of the Puparium.

Amongst the dark-brown puparia I find one grey larva, which differs in a few points from the puparia, to which I paid more special attention; and since the larva, by hardening of the stem, becomes the puparium, the description of the latter will serve, with slight modifications, for the former. The puparium is a dark-brown hard-skinned object, measuring 9 mm. in total length, with a greatest diameter of 2 mm. It is cylindrical, bluntly pointed anteriorly, and produced into a narrow cylindrical tail occupying about one-third of the total length — viz., 3·5 mm. This terminates in a pair of short, narrow tubes, paler than the body, but tipped with dark pigment; each branch or tube is 1 mm. in length, and bears a spiracle at its apex. The entire surface—except these terminal branches—is covered with closely set blackish spines (as in *Eristalis*), groups of which at certain segments become larger and claw-like.

The body consists of a small "head,"* carrying a mouth, followed by ten distinctly marked segments, the last bearing the anus, behind which is the long tail.

There are no definite feet on this puparium, but on the ventral face of each of the eight segments 3 to 10 are paired groups of black claw-like spines, those on the last segment being carried on a prominent median papilla. In the majority of the specimens the ventral surface of the 9th segment is sunk below the general level, and, the body being abruptly curved ventralwards in this region, the claws of segments 8 and 10 are brought close together, and even in contact in some specimens, thus giving rise to clasping-organ.

Westwood's figure shows nothing of this kind, all the segments being represented alike, and he places claws on all ten segments. Packard's figure, however, shows a slight prominence behind the 7th, and another larger one on the 10th. These, however, are wide apart, and do not suggest a clasping-organ.

* Possibly the true head is retracted.

The black claws are not arranged in circles, as they are in *Eristalis*, but in irregular groups, and the number differs in the different segments.

The first segment is armed on the ventral surface with a series of closely set black rectangular plates, each toothed along its hinder margin; these plates are in about half a dozen transverse rows, each row shorter than the preceding, giving rise to a somewhat triangular black patch. The anterior edge of this and of the second segment is also armed with a row of short black conical tooth-like spines.

The "head" bears on either side a small triramous organ, each branch of which is somewhat dilated at its extremity, and is apparently perforated by a minute aperture. Each is traversed by a brownish granular canal (in which I could not detect any rings), which at the base of the organ unites with the other two to form a single canal, which runs backwards for a short distance, then, near the hinder end of the head, dilates to form a hemispherical or conical saccule, which rests against and is partly embraced by a dilated tracheal tube, colourless and distinctly ringed as usual; from this a trachea can be traced backwards into the body. This appears to be an "anterior spiracle" such as occurs in the pupa of several aquatic *Diptera*, such as the gnats and *Eristalis*, though in form it does not resemble the organ in the latter fly.

From each of the posterior spiracles, situated at the tip of each of the forks of the tail, a trachea can be traced forwards into the body, and there is no dilatation except the small one just referred to.

The Larva.

Amongst the dark-brown "puparia" I find one individual which is grey in colour, with a softer and flatter body; the spines covering the body are much longer than in the puparium; each of the ventral paired groups of "claws" is on a distinct prominence or transverse ridge, which appears to represent the paired "legs" of *Eristalis*, the ridge of segment 10 being more prominent than the rest. Further, round each segment, as well as on the "head," is a series of tufts of small pale hairs, no doubt sensory in function. Each tuft consists of three hairs rising apparently from a common base; they are colourless, and much longer than the spines. These sensory hairs are also observable on the puparium, but are less conspicuous. The anterior end bears a pair of dorsal "eye-spots." The mouth is armed on each side with two or three rows of stout spines, and within the cavity is a pair of short antennæ; each appears to be 3-jointed, the terminal joint being brown, and to spring from a circular

convex disc, which I believe forms the anterior end of the real head, which is retracted, as has been observed to occur in *Eristalis*. The mouth leads into a short cylindrical tube, which soon dilates to form a pharynx, in the wall of which a number of sclerites are present, the most conspicuous of which is essentially a ring, with four backwardly directed processes, which no doubt serve for the attachment of muscles. Though built up on the same plan as that of *Eristalis*, it is very different in detail.

Some of the puparia were merely empty skins, and these were cleft horizontally on each side from the head backwards over two or three segments: no doubt the fly had emerged by this slit.

In one case the skin was ruptured somewhere near the middle of the body and exposed the pupa, which occupies only a small portion of this internal cavity; in length it extends through about four segments, and in breadth is only half the diameter of the puparium.

We have, then, the whole series of stages in the life-history of this creature, which I believe from the above-mentioned references to be *Ephydra*, both from its habitat in salt pools and from the resemblance in external form. Moreover, the genus has already been recorded by Captain Hutton as occurring in this country, for he described* *E. aquaria* from Christchurch, which is 5 mm. in length, and this agrees with the length of the pupa in the puparium above alluded to.

No doubt the general history agrees pretty well with that of *Eristalis*, and is as follows: The eggs are laid in the water of salt marshy ground; the larvæ, issuing therefrom, burrow in the mud, where the spinous covering and the specialised claws serve as organs of locomotion, and the tail is directed upwards to the surface for respiration: this probably occurs only at intervals. The larva feeds on the organic matter in the mud, and as the time for pupation approaches it seems that it uses its hinder clawed segments 8 and 10 to cling to algæ floating in the water, for in nearly all the individuals I find threads of algæ held by these prominent segments; and at this time the anterior spiracles perhaps come into use. The skin now becomes hard and dark-coloured. The tissues, as in other cases of similar metamorphosis, become disintegrated, and later on become rearranged, if we may use the term, to give rise to the body of the pupa. The larval skin has become a cocoon or "puparium," and it seems likely that the imago escapes through the anterior end—hence the object of the larva supporting itself by the algæ, so as to allow the anterior end to emerge from the water.

* Trans. N.Z. Inst., vol. xxxiii., p. 90.

EXPLANATION OF PLATE XVII.

Fig. 1. Puparium of *Ephydra*, viewed ventrally, slightly from the right side; claw-bearing segments numbered. *b*, patch of black plates on segment 1. The spines covering the body are omitted from these figures.

Fig. 2. Side view of the hinder part of the body, showing the clasping-organ formed by the 8th and 10th segments.

Fig. 3. Ventral view, in outline, with part of the body-wall cut away to expose the pupa within. *a*, anterior triramous spiracle-bearing outgrowth; *d*, cavity within puparial skin; *e*, pupal envelope; *f*, imago within the pupal envelope, diagrammatically represented; *g*, paired group of claw-like spines on 8th segment; *i*, anus; *m*, mouth; *p*, pharyngeal skeleton (seen through the skin).

Fig. 4. Anterior end of a larva, showing the armature of the mouth and of the anterior margins of segments 1 and 2. *a*, anterior spiracular outgrowth; *b*, triangular group of spinose plates; *m*, mouth; *n*, the base of antennæ (? = true head); *s*, trifid sensory hairs.

Fig. 5. The mouth enlarged, showing the probably "true head" retracted within. *n*, one of the antennæ; *h*, "true head."

Fig. 6. Pharyngeal skeleton of the larva. *m*, mouth; *p*, pharynx.

Fig. 7. Anterior spiracular outgrowth, with its air-canals passing back to the trachea (*t*). At edge of figure is seen a few of the plates (marked *b* in fig. 4).

Art. XXIV. — *Notes on some Nudibranch Molluscs from New Zealand.*

By W. B. Benham, D.Sc., M.A., F.Z.S., &c., Professor of Biology in the University of Otago.

[*Read before the Otago Institute, 11th October*, 1904.]

Plate XVIII.

A few years ago I sent a number of nudibranchs that I had collected at various places round our shores to the Danish specialist, Dr. R. Bergh. A description of these, and of others sent by Mr. H. Suter, has been published in an elaborate monographic serial, which is not likely to be available to naturalists in this colony; nor, indeed, would it occur to students of the New Zealand fauna to search the pages of Semper's "Reise im Philippinen" for information about new species limited, so far as is known, to our coasts. Nevertheless, in the sixth part of Bergh's "Malacologisch Untersuchungen," which forms volume ix. of Semper's Expedition, may be found not only descriptions of our nudibranchs, but others from Tasmania and from Rarotonga; still others from Lamlash Bay, in Ireland; from the coast of Alaska; from South Carolina; and from Porto Rico!

In the interests of students of zoo-geography and local faunas, zoologists ought to protest against this sort of mixture of localities under a title which indicates, if words mean anything, that the contents were collected during an expedition to the Philippine Islands.

However, I have to thank Dr. Bergh for naming and describing these specimens, and for sending me proof-sheets of that part of his valuable "Untersuchungen" that deals with our species. It would have been useful to have reproduced his figures, but I understand from Mr. Hedley that the only figure of an entire animal is reproduced from a sketch of *Atagema carinata* that I forwarded to Bergh; the remaining figures refer only to differences of internal anatomy—many of them of microscopic detail.

In addition to six species the description of which is given in the translation below, Dr. Bergh named for me five other nudibranchs, of which one is *Goniodoris castanea*, Alder and Hancock, which is thus shown to have a very wide distribution, as it occurs on the British coast. Of the remainder, two new species of *Chromodoris*, a new species of *Doriopsilla*, and one of *Aphelodoris* were included in those I sent him, but, as I do not know whether he has yet published a description of these new species, I refrain from giving the specific names at present. These four new species and some of the others were obtained during the two trips of the s.s. "Doto" in which Mr. Ayson, Inspector of Fisheries, conducted a series of experimental trawlings in the years 1900 and 1901, when a considerable number of new and rare species of most groups of invertebrata were obtained.

Of the two new species of *Chromodoris*, one was obtained off the Mahia Peninsula, Hicks Bay, on the east coast of the North Island; the other between Kaipara and New Plymouth, where, too, the *Aphelodoris* was caught: these were carefully preserved by Mr. Hamilton. The *Doriopsilla* was dredged from 30 fathoms in Tasman Bay, in 1900, when Mr. G. M. Thomson was superintending the collection of invertebrates.

One of the most interesting of the molluscs described below is *Homoiodoris novæ-zealandiæ*, since the only other species of this genus occurs in the Japan Sea. We have several other similar facts of distribution amongst our marine invertebrata. I refer, for example, to the peculiar little enteropneust *Dolichoglossus otagoensis*, Benham,* with its grooved proboscis, which is only known in one other species (*D. sulcatus*, Spengel, from Japan). Again, the polynoid *Physalidonotus squamosus*, Qtfgs. (or *Lepi-*

* Trans. N.Z. Inst., 1899, p. 9.

donotus giganteus of Kirk) presents peculiarities, indicated by its generic name,* that have hitherto only been noted in two Japanese polynoids, recently described by Moore† as *Lepidonotus branchiferus* and *L. chitoniformis*, but which probably should be included in Ehler's new genus just mentioned. A second interesting form is *Atagema carinata*, which is now resuscitated from the oblivion that for seventy-five years has surrounded it.

I proceed to give a translation of so much of Bergh's article as deals with the external features of our species (omitting details with regard to internal anatomy), and any remarks of my own will be enclosed in square brackets.

NUDIBRANCHIA KLADOHEPATICA.‡

Fam. TRITONIIDÆ.

Tritonia, Cuvier.

T. incerta, Bergh, n. sp., p. 24.

Of this form I have received from Professor Benham (Otago University) a single specimen, obtained off the east coast of the North Island of New Zealand, between Kaipara and New Plymouth [during the trawling trip of the s.s. "Doto," 1901].

[*Colour.*] The individual, in alcohol, was of a yellowish-white colour.

[*Dimensions.*] The length is 4 cm., with a breadth (without the gills) of 1·5 cm., and a height of 1·3 cm. The breadth of the "buccal veil" is 10 mm., its lobes 2·5 mm., and the tentacles 2 mm. The height of the rhinophore-sheath [hinder tentacles] is 4 cm.; the height of the gills is 4 cm.; breadth of the sole of the foot, 15 cm.; length of tail, 3 mm.

[*Externals.*] It has the form usual in the genus. The "buccal veil" carries altogether seven finger-shaped lobes. The tentacles have the usual form. The retracted rhinophores are 3·5 mm. high, with the usual structure. The back is finely tuberculated. The short arborescent gills, numbering 13–14 on each side, are nearly of equal size. The anus is situated below the 5th gill. The genital pore as usual. The foot is narrowed in front and behind; the margin relatively thin; the tail [metapodium] short.

[p. 25.] This form can scarcely be identified with any of the Tritonias from the Pacific, hitherto sufficiently studied; it

* Ehlers, "Neuseelandische Anneliden," Abhand. K. G. Wiss. Göttingen, 1904.

† Moore, J. P., Proc. Acad. Nat. Sci., Philadelphia, 1903, p. 405.

‡ Semper's "Reise im Philippinen," ix. (Bergh, Malacol. Untersuch vi., 1904).

is distinct from *T. challengeriana* and *T. dioncedea*, while from *T. exsulans* it differs in the buccal veil and the number of teeth at the radula.*

NUDIBRANCHIATA HOLOHEPATICA.

DORIDIDÆ CRYPTOBRANCHIATÆ.

Fam. ARCHIDORIDIÆ.

ARCHIDORIS, Bergh, 1892.†

A. violacea, Bergh, n. sp. [p. 31]. Pl. ii., figs. 36, 37; pl. iii., fig. 1.

This form was frequently obtained by Benham at a depth of 30–40 fathoms at various stations between Otago Peninsula and Oamaru. [I have obtained it in bucket-loads from fish-trawlers.] The living animal attains a length of over 6 in., and a breadth of 2½ in. The colour is a fine violet, with orange-coloured "tentacles" and foot.

[*Dimensions.*] The single specimen [that I sent him before I had ascertained its great abundance], when in alcohol, has a length of 4 cm.; breadth, 2·5 cm.; height, 1·7 cm. The mantle-edge is 5 mm. broad; the foot is 1·7 cm. broad, its margin 3·5 cm. broad; the tail is 5 cm. long. The height of the rhinophore-sheath is 1 mm., and of the rhinophore itself 7 mm. The diameter of the entirely protruded gill is 1 cm.; length of individual branches, 5 mm. Height of anal papilla, 1 mm.

[I am ignorant as to the value or otherwise of these measurements for identification. It seems to me that many of them depend upon the mode of preservation. If slowly killed, with the various parts fully extended—as can be done by means of weak alcohol, cocaine, and so forth—the measurements will be very different from those taken on an individual of the same size killed by plunging into corrosive sublimate or strong alcohol. However, I give these details as they appear in the memoir.]

The *colour* of the preserved specimen is throughout yellowish-white. The back is covered all over with relatively closely set slightly protuberant rounded tubercles of whitish colour, and with a diameter of 4 mm. [These tubercles in life are violet.]

[*Externals* (p. 32).] The form is a longish oval, the back fairly arched. The tubercles towards the margin of the back are smaller and more crowded. The rhinophores are closely foliated. The gills, situated far back, are formed of eight tripinnate members, of which the hindmost are slightly smaller.

* Bergh, Opisthobranchen. Rep. of "Albatross," Bull. Mus. Comp. Zool., Harvard, xxv., 1894, p. 150.

† It may be as well to state that this name replaces the term *Doris*, which is no longer used as a molluscan genus.

The anal papilla is nearly in the centre of the branchial crown. The mantle-flap* is of nearly the same breadth throughout; its under-surface smooth. The foot is rounded in front, with well-defined marginal groove; the margin is not very narrow; the tail short.

[*Remarks* (p. 33).] From its coloration this form probably represents a new species; possibly it is identical with one or other of the "species" recently described from the Pacific Ocean.†

[I confess I do not understand the above remark. If it is merely its coloration that distinguishes it, it seems scarcely probable that that would justify the formation of a new species. I may note that Sir G. Eliot, in his account of the "Nudibranchs of East Africa and Zanzibar,"‡ suggests that his *A. africana* may be identical with this species, and *A. umia* with *A. nannula*. It is rather odd that Bergh does not refer to Abraham's paper in the Proc. Zool. Soc. 1877, in which several opisthobranchs from our coasts are described and figured. It is evident that all our nudibranchs require working over carefully, for it seems likely that the littoral forms have received more than one name. It will be seen, later, that in the case of other species there is the same hesitation or doubt as to its novelty or otherwise. Unfortunately, the valuable memoirs that Bergh has been publishing for some years past are very much too expensive for individual workers to purchase, and none of our libraries possess the work.]

A. nannula, Bergh, n. sp. [p. 33], pl. iii., fig. 2.

Of this form Benham has forwarded seven individuals, obtained at Port Chalmers, Otago Harbour. [I collected some dozens of this bright little species when the s.s. "Ringarooma" was in dry dock, after being at moorings for about a year in Deborah Bay, amongst the seaweeds, *Bryozoa*, sponges, &c., adhering to the bottom of the ship. I collected a considerable number of interesting animals, amongst others the *Goniodoris castanea*, referred to above.]

[*Colour.*] During life they are light-orange-coloured. In alcohol the seven individuals agree pretty well in colour, size, and form. They were entirely yellowish-white.

[*Dimensions.*] The length averages about 18 mm., with a breadth up to 14 mm., and a height of 3 mm.; the breadth of

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* By this I translate "Mantelgebräm."

† R. Bergh: Chall. Repr., p. 85; Die Opisthobr., Alaska, 1894, p. 159 (*A. kerguelensis*); Die Opisthob. d. Sammlung Plate, Zool. Jahrb., Suppl., iv., 3, 1898, p. 501 (*A. rubescens*: *A.* (?) *incerta*); Ergebn. Reise. n.d. Pacific (Schauinsland), Zool. Jahrb., xiii., 3, 1900, p. 222 (*A. nyctea*).

‡ P.Z.S., 1904.

the mantle-flap is about 14 mm. [*sic.*: probably a misprint]. The height of the gills is 4·5 mm.; breadth of the foot, 7 mm.

[*Externals.*] Form as usual. The back is entirely covered with almost hemispherical papillæ, not very variable in size, but somewhat smaller at the mantle-edge. The club of the rhinophore is much foliated, the foliæ stiffened in the usual way with long spicules. The branchial region is in all the individuals much everted, and surrounded by the narrow lip of the distended gill-opening (which measures 6 mm. in diameter). The gill is formed of five to seven tripinnate members: the upright anal papilla completes the branchial circle posteriorly. The under-surface of the mantle-edge is smooth; the tentacles appear to be shortly conical; the foot is fairly broad, rounded in front, with a short tail.

[*Remarks* (p. 34).] This form is undoubtedly an *Archidoris*, but whether it represents a distinct species must remain for the present undecided.

Archidoris, sp. [p. 34].

The single specimen obtained by Benham at Kaikoura, on the east coast of the South Island, was, in life, pale-orange in colour.

[*Colour.*] The specimen in alcohol was much hardened, broken, somewhat contracted, and uniformly light-yellowish.

[*Dimensions.*] Length, 23 mm.; breadth, 16 mm.; height, 10 mm. Breadth of mantle-flap, 3 mm.; of the foot, 13 mm. The height of the rhinophore, 2 mm.; the diameter of the circular branchial aperture is 4 mm.; height of the gill, 3 mm.

The animal was somewhat hard and stiffened; the back fairly smooth, but finely granulated towards the margins; the rhinophores, lying far forward, has its club much foliated. The foot is large; its margin not broad; the tail short.

[*Remarks* (p. 35).] This form is probably identical with one of the recently described species of the genus.

Homoiodoris, Bergh, 1881.

Hitherto only one species of this genus, *H. japonica*, has been described, and this from the South Japan Sea.

H. novæ-zealandiæ, Bergh, n. sp. [p. 35], pl. iii., figs. 3–7.

Of this form five individuals were received from Mr. H. Suter, who collected them at Port Chalmers.

[*Dimensions.*] The specimens preserved in alcohol had a length varying from 12–20 mm. In the largest individual the breadth of the body is 13 mm.; the height, 7 mm.; the width of the mantle-flap is 3·5 mm.; that of the border of the foot is 3 mm.: the length of foot is 16 mm.; its breadth, 7 mm.;

the tail, 2 mm. The height of the (retracted) rhinophore is 2 mm.; length of tentacle, 1 mm.; height of the gill, 3 mm.; diameter of the branchial star, 7 mm.

[*Colour.*] The colour of the back is whitish or faintly yellowish white; the tubercles white; the head and foot inclining to yellowish; the clubs of the rhinophore and the gill are chrome-yellow. One individual had the under-surface of the mantle-flap spotted with violet-grey.

[*Externals.*] In consistency the animal is somewhat stiff. The form as in other Archidorids. The back is covered pretty closely with tubercles of dissimilar size, somewhat flattened on the apex (at least in the case of the larger ones): they attain a height and diameter of about 0·5 mm. Similar tubercles are also present at the edge of the rhinophore-pits and gill-aperture. [p. 36] The club of the rhinophore bears about 20 foliæ; the branchial aperture is transversely oval; the gills number 5 or 6; the cylindrical anal papilla is relatively high (1 mm.). The under-surface of the mantle-flap is smooth; the sides of the body angular. The foot has a distinct groove at its anterior edge; the tail is short; the tentacles are short, thick, with grooves on the under-side.

[*Remarks* (p. 37).] Whether this form belongs to the genus *Homoiodoris* remains for the present undecided, since the most essential character—the armature of the vagina—was not established owing to the condition of preservation. If this armature noted [in the text] belongs to the sperm-duct, either a new genus will have to be formed, or it belongs to the genus *Artachæa*,* in which, however, no prostate is developed. The vestibular glands and sac existing in the present species are absent from *Homoiodoris* and from *Artachæa*. From the hitherto known species of *Homoiodoris*, as well as of *Artachæa*, this new form is, however, specifically distinct, as is evident from the comparison of the radula—the innermost as well as the outermost teeth being quite unlike those of other species.

Atagema, Gray [p. 39].

Gray, fig. iv., 1850, p. 104; Guide, i., 1857, p. 209.

Form and internal structure as in an Archidorid. The back carries a median keel. As was so frequently the case, Gray erected a new genus (*Atagema*) on a drawing (by Quoy and Gaimard) of an animal presenting a somewhat peculiar appearance.

The animal described below belongs to the *Archidoridida*: it has the general body-form of the family, with granulated

* See Bergh, "System d. Nudibranch: Gasteropoda," 1892, p. 1093.

back and a widish mantle-flap, with tri- or quadri-pinnate gills, small tentacles, and rather stout foot. The oral disc (*Lippen-scheibe*) is unarmed; the radula has a narrow naked rhachis, and numerous hook-like plates. Within this large family of Dorids it approaches most nearly the genus *Archidoris*. It shows well the short finger-shaped tentacles and the relatively small number of gills. The penis and vagina are both unarmed. Apparently the only peculiarity about the animal is the dorsal keel, and it must for the present remain doubtful whether Gray was justified in founding a new genus on this character alone.

Atagema carinata (Q. and G.). *Doris carinata*, Q. and G., Voy. de l'Astrolabe, ii., p. 254, pl. 16., figs. 14–16. *Atagema carinata*, Gray, fig. iv., p. 104. [Bergh figures it] pl. iii., figs. 8–11.

An individual of this species lies before me, obtained by Dr. Benham from Dusky Sound, at the south-west corner of the South Island. The living animal is pure-white. The sketch made by Benham (fig. 8) is from an individual preserved in formol.

[I exhibited a specimen of this Dorid at a meeting of the Otago Institute in 1898,* and drew attention to the fact that it was the "*D. carinata*" of Quoy and Gaimard. Since sending the specimen to Dr. Bergh, I have received from Mr. R. Henry, at Dusky Sound, others of a larger size—viz., length, 8–9 cm.; breadth, 6–7 cm.; height, 3·3 cm.]

The specimen in alcohol is much arched, contracted, and hardened; it had been broken. It is now yellowish-white in colour.

[*Dimensions* (p. 40).] The length was [in an extended condition] probably 5–6 cm., with a breadth of 4 cm., and a height 2·5 cm. The dorsal keel has at its greatest length a breadth of 5–7 mm.; it is narrower in front and behind, while posteriorly to the protuberance its height is 5 mm. The width of the mantle-flap is at least 12 mm., and its thickness at the base is 7 mm.; the height of the rhinophore-sheath is 4 mm., and of the branchial papilla 4 mm.; the breadth of the foot is 22 mm., and of the margin of the foot 4 mm.

[*Externals.*] The consistency is leathery; the back is quite finely shagreened. The form is oval, with a somewhat arched back; the mantle-flap broad, and the foot projecting all round. The back carries a great median keel, which commences anteriorly between the rhinophores. It is at first somewhat low and narrow, then becomes thicker, and behind the middle

* See Trans. N.Z. Inst., xxxi., p. 743.

of its extent becomes elevated into a blunt point; thence it continues as a much narrower ridge to the gills. The projecting rhinophore-sheath has a circular aperture. The club of the retracted rhinophore is 4 mm. high, is closely foliated, and terminates in a small papilla. The branchial cone consists of four converging lappets (5 mm. high) with rounded ends. The deeply sunk gill is formed of six* tripinnate members, 7 mm. high, of which the two anterior are the larger. The relatively thin anal papilla, which is 3 mm. high, is curved forward, and subcentral in position. The retracted tentacle is 2 mm. high, short, finger-shaped with a groove on the underside. The foot is stout and broad, rounded in front, with a marginal furrow; the tail is relatively short.

[*Remarks* (p. 41).] The animal here described appears really to represent the *Doris carinata* of Quoy and Gaimard, which since the expedition of the "Astrolabe" in 1828 has not been met with. The French zoologists obtained the animal in New Zealand [in the estuary of the Thames, Hauraki Gulf]. The size (*très petite espèce*) of the individuals examined by them appears, however, to have been very much less [than the specimens now under consideration], the colour yellowish-white, and the number of gills only four.

[In view of the interest of this species I append figures of a specimen, natural size, in side view and from below (see Plate XVIII.).]

Art. XXV.—*Note on the Function of the Last Pair of Thoracic Legs in the Whale-feed* (Grimothea gregaria).

By Chas. Chilton, M.A., D.Sc., F.L.S., Professor of Biology, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 30th November,* 1904.]

Plate XIX.

The whale-feed, *Grimothea gregaria* (Fabr.), which is so common around the southern coasts of New Zealand at certain seasons of the year, belongs to a division of the Crustacea generally known as the *Anomura*, a group intermediate in many characters between the *Brachyura* (crabs) and the *Macrura* (crayfishes, lobsters, &c.). In the *Anomura* the thoracic legs of the fifth pair are generally small and weak, and thus markedly different from the preceding pairs of legs. In giving the characters of

* In specimens in my possession I find the branchial cone to consist of five lappets or valves, and the gill consists of five members (Benham).

the *Macrura anomala*, a group including the majority of the Crustacea generally classed as *Anomura*, the Rev. T. R. R. Stebbing says,* "The fifth pair of legs are generally weak, not fit either for walking, swimming, or grasping food or prey." In many of the free-swimming forms, such as *Grimothea*, these legs have the joints of the limb folded against one another like the limbs of the letter Z, and the whole appendage is carried at the side of the carapace above the bases of the more anterior legs, and in this position they have the appearance of being quite useless; and I am not aware that any function has ever been assigned to the fifth pair of legs in this section of the *Anomura*, though in another family, the *Lithodidæ*, where the fifth pair of legs are slender, chelate, and folded in the branchial chambers, Mr. Stebbing has suggested that they may be used to keep the branchial clear of parasites, and thus be of advantage to the animal.†

During a short stay at the Marine Fish Hatchery and Biological Station at Portobello, in November, 1904, I had opportunities of observing living specimens of *Grimothea gregaria*, and one day while watching a small specimen under the dissecting microscope I was much interested to see the animal suddenly unfold the fifth pair of legs, stretch them forward over the anterior portion of the carapace, and with the tuft of setæ on the terminal joints carefully brush away extraneous matter from the dorsal surface of the carapace, and particularly from the spaces between the rostrum, the eyes, and the bases of the antennæ. The action was quite unexpected, and was almost ludicrously like that of a person engaged in brushing his back hair. For the purpose in question the fifth pair of legs of *Grimothea gregaria* seem well fitted—they are just long enough when unfolded to reach conveniently to the anterior portion of the carapace; and the two terminal joints (propodos and dactylus), which are bent nearly at right angles to the preceding joint, and when at rest are curved behind the bases of the fourth pair of legs, are supplied with numerous long setæ projecting radially from them, one row of setæ being curved and pectinate, and the whole forming a sort of circular brush specially adapted for sweeping out the spaces between the spines of the rostrum, around the bases of the eye-stalks, &c. These two joints, moreover, form a chela or pincers with the fingers somewhat spoon-shaped, and are doubtless used to pick off substances that cannot be brushed away.

As the *Grimothea gregaria* swims rapidly backwards by means of alternate flexions and extensions of its abdomen,

* "History of Crustacea," p. 149. † *l.c.*, p. 155.

any floating matter in the water would naturally tend to settle in these spaces, and would interfere with the proper use of the eyes; and there seems little doubt that the fifth pair of legs are of advantage to the animal in keeping these spaces clear, and in preventing parasites lodging therein.

It is comparatively seldom that one has an opportunity of observing the habits of marine animals, and the use that is made in this case of a pair of appendages that have all the appearance of becoming vestigial is perhaps worth placing on record.

EXPLANATION OF PLATE XIX.

Fig. 1. *Grimothea gregaria*, fifth thoracic leg (× about 15).

Fig. 2. *Grimothea gregaria*, extremity of the same (more highly magnified).

Art. XXVI.—*On the Occurrence of a Species of* Cercaria *in the Cockle.*

By Chas. Chilton, M.A., D.Sc., F.L.S., Professor of Biology at Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 30th November*, 1904.]

Plate XIX.

During the month of November, 1904, I spent a short holiday at the Portobello Fish-hatchery and Biological Station, and on the morning after my arrival the curator, Mr. T. Anderton, brought me a cockle (*Chione stutchburyi*) evidently infested with some parasite. On examination this proved to be the sporocysts of some species of *Distomum* containing numerous *Cercariæ*, in most cases just ready to escape from the sporocyst. Subsequently the sporocysts were found in two or three other specimens of the cockle, but, though numerous in those specimens in which they were found, they were not often met with—certainly not in 1 per cent. of the cockles examined.

Similar *Cercariæ* have been long known to occur in various molluscs in Europe, but so far as I am aware the only forms hitherto recorded from New Zealand are the two described by Professor Haswell from *Mytilus latus*;* and, as my specimens differ from these and from all the others that I can find descriptions of, I give here a brief description of its general form, mode of occurrence, &c. It appears to come very near to *Cercaria villoti*, Monticelli (= *C. setifera*, Villot),† but differs from that

* Proc. Linn. Soc. N.S.W., 1902, p. 497.

† See Korscheldt and Heider, "Embryology of Invertebrates," part i. (English edition), p. 186; and Villot, "Annales des Sciences Naturelles," Zool., viii., p. 33. (I am indebted to Professor Benham for these references.

species in the character and arrangement of the setæ on the tail, and I propose to give it the name *Cercaria pectinata.*

Cercaria pectinata, n. sp. Plate XIX.

Similar to *C. villoti*, Monticelli (= *C. setifera*, Villot), but with the "setæ" arranged in two rows along the sides of the tail, instead of forming rings around it; each "seta" consisting of a short vertical row of long bristles.

Hab. In *Chione stutchburyi*, Otago Harbour.

General Notes.

The sporocysts (fig. 1) were numerous in each cockle in which they were found, particularly in the first one, in which there must have been several hundreds. They were lying external to the body in the spaces between the mantle-lobes, the gills, &c. Each sporocyst is about 4 mm. long and 0·75 mm. broad, sausage-shaped, but somewhat narrowed at each end, both ends being alike. By alternate contractions and expansions they were capable of creeping about somewhat slowly with a worm-like motion. The whole of the interior of each sporocyst was in nearly all cases filled with fully developed *Cercariæ* just ready to escape, and through the semi-transparent walls of the sporocysts these *Cercariæ* could be seen often moving about within. The number of *Cercariæ* in each sporocyst varies to some extent, but usually there were a dozen or more. Swimming among the sporocysts were numerous *Cercariæ* that had already escaped, and if a sporocyst were artificially ruptured the contained *Cercariæ* at once began to swim freely about. In a few cases the *Cercariæ* were seen escaping naturally through the walls of the sporocyst, and in these cases they made their way through the lateral wall and were apparently able to penetrate this at practically any point.

Occasionally the sporocysts contained, besides fully developed *Cercariæ*, one or two rounded or elongated masses of cells, presumably immature *Cercariæ*, but in most of the cases observed they contained nothing but fully developed *Cercariæ*.

The *Cercaria* (fig. 2) has a long powerful tail nearly twice as long as the head; this tail sometimes showed numerous fine transverse lines or striæ, most evident anteriorly, but these were not made out in all cases. Along each side of the tail is a series of "setæ," and by the rapid vibrating action of the tail, combined with the use of these "setæ" as fins, the *Cercaria* is able to swim rapidly through the water. When viewed from above during life each "seta" (see fig. 3) appears to be simple, but closer observation shows that each is made up of a number of fine long bristles arranged in a short vertical row and united together at the base so as to form a comb-like structure, the

teeth of which are, however, very long. These bristles are held together by fine transverse connections, and when in action during life are kept in the one plane and moved as a single structure, but in preserved specimens they become separated and spread out towards the distal end. The tail is also capable of considerable contraction and expansion, and its proportionate length and width accordingly varies greatly, but in the condition most usually maintained the width is about one-eighth of the length.

The head is usually more or less rounded when the *Cercaria* is swimming freely, but in addition to this mode of motion the *Cercaria* can creep along by means of the worm-like motions of the head caused by contraction and expansion, and accordingly the head then assumes other shapes and may be much elongated. In fig. 2 the anterior portion is shown in the act of contracting and consequently widening, while the posterior portion is still elongated. The general colour of the whole *Cercaria* is whitish, semitranslucent, but on the head there are usually a number of small irregular pigment-spots of a light-brown colour.

The general structure of the *Cercaria* appears to present the usual features: the buccal sucker is situated at the anterior extremity, and is the foremost portion when that part of the body is being extended; the posterior sucker is about equal in size to the anterior and is situated a little anterior to the middle of the head; in fig. 2 it appears rather nearer the anterior end owing to the contraction of that portion of the head. There is a well-marked cuticle, and around the anterior sucker this bears a number of fine short setæ. The internal organs are well developed; during life the most conspicuous is a large V-shaped structure extending from the posterior extremity of the head nearly to the anterior end, and presumably representing the contractile bladder of the excretory system; in life this is darker than the rest of the head, and is filled with minute granules. The central portion of the tail presents much the same appearance, but whether the bladder actually extends into the tail or not I am not certain.

The alimentary system is also well developed and of the usual structure; the pharynx is small, nearly circular, and situated close up to the buccal sucker; the œsophagus narrow and short, and the two lateral branches of the intestine are also narrow.

The reproductive organs also appear to be well developed in most of the *Cercariæ* examined, and in one which was accidentally ruptured while under examination I saw mature spermatozoa; in some the genital aperture could be seen about midway between the two suckers, and connected with it an oval structure extending back as far as the posterior sucker and apparently representing the rudiment of the genital atrium. I have, however, not

attempted to make out the arrangement of the different parts of the reproductive system. In specimens killed in osinic acid two small masses staining deeply with the acid are usually very prominent, one on each side, a little behind the posterior sucker.

As the *Cercariæ* on leaving the sporocyst may readily escape from the cockle and swim freely in the sea-water, it may thus reach a great variety of animals, and in the meantime I am unable to offer any suggestion as to the host in which the adult fluke is likely to be found.

EXPLANATION OF PLATE XIX

Cercaria pectinata.

Fig. 1. Sporocyst containing *Cercariæ* (× about 10).
Fig 2. *Cercaria pectinata* (× 60).
Fig. 3. *Cercaria pectinata*: one of the "setæ" from the tail (highly magnified).

ART. XXVII.—*Notes on Fruit-flies, with a Description of a New Species* (Dacus xanthodes).

By Captain T. BROUN, F.E.S., Government Entomologist and Fruit Inspector at Auckland.

[*Read before the Auckland Institute, 27th February,* 1904.]

THESE two-winged flies are, without doubt, the most dreaded of all orchard pests, and consequently strenuous efforts are made to prevent their establishment in New Zealand. The most important species from our point of view are the Mediterranean fly (*Halterophora capitata*) and the Queensland one (*Tephritis tryoni*).

The Mediterranean species is known to occur in widely distant countries, including Malta, Sicily, Azores, Madeira, Cape Verde Islands, Bermuda, Cape Colony, Mauritius, Cuba, and Australia. European records of its ravages extend as far back as the year 1826, when it was stated that "fully a third of the oranges shipped to London from the Azores were rendered unfit for use before they reached their destination through the presence of this maggot before they were packed." In 1890 an article appeared in the American publication called "Insect Life" wherein this fly was described as a peach-pest at Bermuda. During 1892 Mr. J. H. Cooke stated that "all the oranges in Malta had been destroyed for the past few years by the maggot of this fly." The opinions of competent observers and responsible officials only have been quoted here. Besides the fruits already mentioned, about fifteen others have been attacked.

The Queensland fly was, I believe, first recognised in that colony in 1887, but it was not described until 1897, the date of the report prepared by Mr. W. W. Froggatt for the Government of New South Wales. This insect in Australia does not appear to breed further south than Newcastle, New South Wales—about our 33rd parallel of latitude; but it has been plentifully found here in fruit imported from the tropical islands situated north-east of New Zealand.

Before proceeding further it may be stated that, relying solely on the results of the inspection of fruit landed at Auckland, the Mediterranean fly has not been reared here except from maggots found in fruit imported from Sydney, none at all having been bred from "island" fruit. As this species thrives in comparatively cold climates, and attacks almost all kinds of fruit, we must carefully guard against its introduction.

When dealing with importations of fruit infested with different kinds of insects an Inspector must apply special methods for their destruction before delivering such fruit to importers. In the case of scale insects, which are exposed on the outside of the fruit, the whole consignment is subjected to the action of hydrocyanic-acid gas within an air-tight chamber for an hour. This treatment destroys the insects, but does not remove their scales or waxy coverings. The fly-maggots, on the other hand, cannot be destroyed by artificial means, unless by burning the fruit itself, as the maggot until mature or full-fed is secure within the fruit, there being only a minute hole through its skin formed by the ovipositor of the female fly whilst inserting her egg. When an Inspector detects the presence of these maggots in a case of fruit, all the other cases forming that particular consignment and branded with the same mark are soon afterwards burned in a furnace. As many as 450 cases belonging to one lot and consigned to one importer have been destroyed in that way, thereby causing a serious loss to the importer or shipper. The only exception to this rule applies to the islands of the Cook Group, recently annexed to New Zealand. In this instance only a consignment found to be infested with these maggots may be picked over under the Inspector's supervision. *Each fruit* is examined separately: if infested it is put aside for burning, but those found to be free from this pest are handed over to the importer, who therefore only loses the infected fruit.

During the year from 1st April, 1902, to the 31st March, 1903, there were ninety-one different lots, comprising 4,119 cases, of fruit condemned at Auckland alone on account of these maggots. All these consisted of "island" fruit.

The maggot of the new species (*Dacus xanthodes*) does not differ materially from those of the other flies specially alluded to.

It was discovered here in one pineapple imported from Rarotonga on the 5th December, 1903, and on the 14th of that month Mr. G. Harnett, Assistant Inspector, and I again detected it in two cases of pineapples from Suva. We also found it on various occasions afterwards in oranges, grenadillas, and mammæ-apples from Tonga and Rarotonga. The perfect flies were subsequently reared here from the maggots in considerable numbers, so that this new pest threatens to become as troublesome and injurious as the Queensland fly.

Dacus (Tephritis) xanthodes, sp. nov.

Imago.—Length of body, 4½ lines; expanse of wings, 7½ lines.

Body elongate, yellow, occasionally testaceous, extremity of abdomen blackish, head sometimes rufescent, tarsi infuscate; on the thorax, from base to apex, there is a central pale ivory-like streak, along each side there is a similar one; these lines after death become less conspicuous.

Head as broad as the thorax, smooth; on its back part there are four black outstanding setæ, and between the eyes six finer ones. *Antennæ* normal, their terminal joint elongate and rather darker than the others; at the tip of the preceding one arises a very long seta, which, though stout at its base, becomes very slender and darker towards the extremity. *Eyes* large, prominent, their inner edges straight and moderately distant from each other; they are finely facetted, and of a brilliant purple during life. *Thorax* cylindrical or subovate, nearly twice as long as it is broad, with two slight almost equidistant constrictions at each side; the surface bears numerous minute black granules, from each of these proceeds a fine dark hair; at the base, which is deeply emarginate, there are two long rigid conspicuous black setæ directed horizontally backwards, four smaller ones are situated just before the posterior constriction, and about an equal number along each side. *Hind-body* quite the length of the thorax, its basal three segments, irrespective of the narrowed anterior portion, of the same length and breadth, thus forming a cylindric figure, fourth segment rather shorter and narrowed behind, the terminal elongate and tapering towards its apex, with very fine grey hairs; the preceding segments are minutely sculptured and bear many dark slender hairs.

Legs stout, moderately elongate, with short black hairs; posterior tibiæ somewhat arcuate. Tarsi elongate, pilose, their basal joint rather more than half of their entire length, fifth bilobed; claws black and rather small.

Halteres yellow, medially slender, clavate and triangular at the extremity.

Wings hyaline, unspotted, with pale-brown nervures corresponding in structure with those of *Tephritis tryoni*.

Underside flavescent, not maculate, except at the apex of the last ventral segment, which is piceous. The abdominal segments are concave, or so deeply hollowed that the sides and upper surface appear quite thin.

Female.—Hind-body elongate-oval, terminal segment rounded and not prolonged; on each side of the uncovered second segment there is a small cluster of fine black setæ: these do not occur in the other sex.

This species differs from Froggatt's *Tephritis psidii* in being larger, differently coloured and sculptured, and without dusky areas on the wings. From *T. tryoni* it is distinguished by the greater length of the body and expanse of wings, uniform coloration, without fuscous or yellow marks, dissimilar clothing and sculpture, less broadly oviform or wasp-like hind-body, and stouter antennal setæ. In *T. tryoni* the flanks of the sternum are fuscous.

Art. XXVIII.—*On some New Species of* Lepidoptera.

By Alfred Philpott.

Communicated by G. V. Hudson.

[*Read before the Wellington Philosophical Society, 2nd November*, 1904.]

Plate XX.

Melanchra decorata, n. sp. Plate XX., fig. 2.

♂, ♀, 38 mm. Head and palpi grey-yellowish. Antennæ simple in both sexes. Thorax with strong anterior bifid crest, less pronounced in ♀, grey-yellowish mixed with brown; patagiæ outwardly bordered with brown; a white line on collar followed by a black line. Abdomen with series of crests, grey-yellowish. Fore wings: Costa almost straight, termen slightly waved and faintly sinuate, *pale brownish-yellow* (in some examples tinged with pink) *mixed with whitish on basal half of costa*; a very dark reddish-brown shade from middle of base to termen above tornus, *bordered beneath from about* ⅓ *by conspicuous white fascia which is bent sharply upwards at* ⅔; a short brown streak from base below middle; orbicular oblique, faintly outlined in brown; reniform large, pale, outlined in brown; space between orbicular and reniform dark reddish-brown, connected with costa by narrow projection; two brown spots on costa above reniform; a faint double waved line from costa at ⅔; subterminal indistinct, pale, waved, bordered with bright reddish-brown; veins faintly

marked with brownish; cilia brownish-yellow, suffusedly barred with dark-brown. Hind wings fuscous, tinged with pink, lighter near base; cilia grey with dark line.

Very distinct; it is perhaps allied to *M. diatmeta*, but is not likely to be mistaken for that species. The single male I possess is not in good condition, and does not show the markings to the same extent as the female. The species is figured from a ♀ in fine condition lent to me for the purpose by Mr. Robt. Gibb, of Tuturau.

A rare species, taken in October at "sugar." West Plains, Tuturau.

Melanchra levis. Plate XX., fig. 4.

♂, ♀, 35 mm. Head and palpi dull-greenish. Thorax with strong thick pointed anterior crest, greenish-brown; collar broadly yellowish-brown; patagia brighter green. Abdomen dull-brownish, slightly greenish-tinged. Fore wings: Costa straight; apex rounded; termen straight, rounded beneath, *brown faintly tinged with green, markings very obscure, blackish*; a thin double line near base; a suffused patch at angle of dorsum near base; a faint curved line at ⅓, *followed by oblique interrupted line not reaching dorsum*; a fine bent line at ⅔ posteriorly bordering orbicular and becoming obsolete at middle of wing; a similar line anteriorly bordering reniform; subterminal line pale-greenish, suffusedly and interruptedly bordered with blackish; cilia pale-greenish mixed with brown. Hind wings greyish, fuscous, paler towards base, cilia grey with obscure darker line.

Belongs to the smaller *exquisita-coeleno* group, but does not closely resemble any species.

Taken at "sugar" sparingly in September and October. West Plains.

Leucania stulta, n. sp. Plate XX., fig. 1.

♂, ♀, 41 mm. Head, palpi, thorax, and abdomen pale-fawn; dark line on collar, suffusedly bordered with whitish. Antennæ brown, basal portion whitish, shortly ciliated in male. Fore wings slightly dilated; costa uniformly arched; apex round-pointed; termen slightly oblique, rounded; *pale-fawn*; markings dark reddish-brown; a short streak from near base beneath to ⅓; a suffused irregular streak from middle of base to termen above anal angle, almost interrupted before middle; *a suffused streak from ⅓, attenuated anteriorly and much dilated towards termen, divided on lower portion by whitish borders of veins*; one or two short apical streaks above this; cilia brownish on termen, fawn beneath. Hind wings fuscous; cilia whitish with dark line.

Not easily compared with any other *Leucania*.

October to December. Not common. I have not taken the male at West Plains, and have figured that sex from a specimen kindly supplied by Mr. Gibb, who has taken a few examples at Tuturau.

Leucania neuræ, n. sp. Plate XX., fig. 5.

♂, 36 mm. Antennæ strongly dentate, fasciculate; brown, with white spot at base. Head and thorax dull ochreous-brown. Abdomen pale greyish-brown. Fore wings: Costa straight, apex slightly rounded, termen straight, rounded beneath; *dull-brown; veins sharply marked in black with scattered white scales*; a white spot on vein 1*b* at $\frac{1}{4}$; a conspicuous white spot at origin of veins 3 and 4; a curved series of white dots on veins from about $\frac{4}{5}$ of costa to $\frac{4}{5}$ of dorsum; cilia same colour as wing, tips whitish. Hind wings dull-fuscous, paler at base and dorsum; cilia pale greyish-white with darker line.

Distinguished from *L. micrastra*, its nearest ally, by the smaller size, duller colour and paler cilia of the hind wings. *Leucania toroneura* differs from this species in the much lighter ground-colour and the absence of white spots.

Two males taken at "sugar"; date uncertain. West Plains.

Xanthorhoe imperfecta, n. sp. Plate XX., fig. 6.

♂, ♀, 29 mm. Head, thorax, and abdomen brownish-ochreous. Fore wings ochreous, in male often reddish on costa and about apex. *The usual lines are in the male reduced to irregular blackish costal spots; in the female these costal spots give rise to very faint transverse waved lines.* White spots follow most of the dark costal spots, and there is a fairly conspicuous pair at $\frac{2}{3}$; cilia ochreous, barred with blackish. Hind wings ochreous; cilia greyish-ochreous mixed with darker.

Nearest to *X. ægrota*, but easily distinguished by the brighter ground-colour and the white costal spots.

Fairly common in low-lying bush districts in January. West Plains; probably generally distributed in suitable localities.

Xanthorhoe recta, n. sp. Plate XX., fig. 3.

♂, 31 mm. Head, thorax, and abdomen ochreous. Fore wings moderate, greyish-ochreous, irregularly suffused with reddish especially towards costa, markings brownish; first line before $\frac{1}{3}$, curved, anteriorly edged with grey; *median band formed of three or four thin lines with narrow spaces of ground-colour between; the first of these is almost straight and rather darker than the others*; the posterior edge of the last one is irregular with two strong projections below middle; this is fol-

lowed by a narrow band of pale-greyish, almost white in some examples; a broad band of brown from $\frac{4}{5}$ of costa to tornus, posteriorly waved and followed by a waved pale line; *cilia long, brownish-pink.* Hind wings long, narrow, pale-yellow; a terminal series of indistinct linear brownish spots; *cilia pink.*

Apparently allied to the *clarata* group, but not closely approaching any species.

Received from Mr. J. H. Lewis, Ida Valley. Mr. George Howes has also met with it near Dunedin.

ART. XXIX.—*Notes on the Occurrence of some Rare Species of* Lepidoptera.

By A. P. BULLER, F.E.S.

[*Read before the Wellington Philosophical Society, 6th July,* 1904.]

Dodonidia helmsii, Butler.

It will, I feel sure, be of interest to entomologists to hear that this beautiful butterfly appears to be on the increase. In February of 1903 Mr. H. W. Simmonds, of Wellington, took fifteen specimens on the birch-clad range above Silverstream, and saw some twenty-five or thirty on the wing. He tells me that it is a strong flier, and is very evasive of capture. It appeared to be very local in its habitat, and frequented for the most part the outskirts of a small patch of birch forest on the very ridge of the hill. Mr. Simmonds found it impossible to pursue it through the fern and scrub, but by posting himself at the opening of a glade in the bush he netted most of his specimens as they flew in, to seek, apparently, the shade. In February of the present year he again visited the same locality, but this time was less fortunate, for since the previous season the patch of bush that had been so productive had been partly destroyed by fire, and though he saw a few he was unable to capture any. To some extent this might have been accounted for by the fact of its being dull, cold weather and a little late in the month. He met with one on the low ground at the foot of the range, but with this exception they appeared to keep to the high level. I took one at the latter end of the same month at Lake Papaitonga, Ohau (Manawatu), on the flowers of the white *Escallonia.* It is the only occasion I have seen it on the wing, and I was much struck by its beauty as it hovered over the blossoms.

In passing, I would strongly recommend collectors to plant a few trees of the *Escallonia* (*Escallonia montevidensis*) in their gardens, as it possesses a singular attraction for insects of all kinds. This tree in particular, and which I had planted for the

purpose, seems, when in flower, to be the "Mecca" of the insect world in the neighbourhood. Throughout the day it is alive with *Vanessa gonerilla, Chrysophanus salustius, C. enysii, Lycæna phœbe, Nyctemera annulata*, and many varieties of *Diptera*; at dusk it furnishes a harvest of *Noctuæ*. It comes into blossom about February and flowers freely till the end of March; it grows readily, and is of hardy habit.

Of the seven specimens of *Dodonidia* in my collection, four were taken by Mr. Simmonds at Silverstream, one was taken on the Wainuiomata Range, one at Papaitonga, and another on the high lands in the Marlborough District.

Chærocampa celerio, Linn.

I think this will be the first record of the appearance of this handsome moth in New Zealand, and it will, I hope, take its place in our list of *Sphingidæ*, at present only represented by *S. convolvuli*. In March of the present year Mr. Creagh O'Connor took two very fine specimens at Titahi Bay (about fourteen miles from Wellington), and during the same month saw some ten or twelve others there. The two he netted were taken at dusk while feeding at the sweet-scented Christmas lily; they appeared to affect garden flowers generally, but were difficult to capture, being very active on the wing, and when once alarmed would not return.

Mr. G. V. Hudson tells me that he has recently received a specimen from Nelson. Noting the fact that it has appeared at two places on the West Coast, it is not unlikely to be an Australian species brought over to New Zealand by westerly winds, in view of the fact that the hawk-moth family are possessed of sustained powers of flight; indeed, I might mention that I have in my collection a fine *Sphinx* that flew on board the R.M.S. "Ruahine" when the vessel was some five hundred miles off the coast of South America. It is to be hoped that this species will become established here, for with its bars of gold on the thorax, its silver-striped upper wings, and the delicacy of its pink underwings, it will certainly be a very handsome addition to our list.

Sphinx convolvuli, Linn.

To the best of my knowledge, this species has so far been confined principally to the Auckland District, where I have taken it freely at the blossoms of the evening-primrose and trumpet-flower, but it appears now to be having a wider range. Five specimens were brought to me at the end of this summer, all taken in Wellington and its environs. Mr. O'Connor has also taken it, and I learn, too, that it has been seen freely in Nelson, and also at Ashburton (Canterbury).

Achæa melicerte, Meyr.

The first and, I believe, the only record of this moth in New Zealand appears in the Transactions of the Philosophical Society in 1876,* in an article contributed by the late Mr. Fereday. He states that a specimen was taken at Wellington by Mr. Liardet, and he describes and figures it as *Catocala traversi*. In his paper he mentions that one had been taken at Lyttelton two years previously, and that he understood it to be a common moth amongst the gum-trees in Australia.

Mr. Hudson tells me that, as far as he knows, this is the only record of its appearance, and until recently these have been the only two specimens known. (Mr. Meyrick has described it in the Transactions† as *Achæa melicerte*, but does not mention *Catocala traversi* as a synonym. From his description, however, it seems clear they are one and the same, and I have adopted Mr. Meyrick's nomenclature.)

It is now interesting to note that it has occurred somewhat plentifully at Titahi Bay, where, early in March this year, Mr. O'Connor took no less than eight or ten in one day, and saw as many more. He was collecting on a steep hillside shelving down to the beach, over which a fire had some time previously run, destroying most of the scrub but leaving here and there a few isolated bushes. On beating these the moths flew out, and, not knowing it to be such a rarity, he kept only five or six. He tells me that they would fly for fifteen yards or so and then settle, but would be off again on his approach. The day being very bright, this alertness rather points to the fact that they may be diurnal in their habits. A little later in the month he took one specimen at rest in a garden in Wellington.

The occurrence of this moth after being practically unknown for nearly thirty years is a matter of much interest and conjecture.

Utetheisa pulchella, Meyr.

This daintily coloured species has also been taken at Titahi by Mr. O'Connor. In January last he took ten in one day, some being at flower on the white rata, and the others he netted in the tussock-grass. He states that it has a feeble flight, and is easily captured. This was the only occasion on which he saw it.

The only New Zealand specimen I have seen is in Mr. Hudson's collection, and was taken by him at Wainuiomata in 1886. A specimen was taken at Petone by the late Mr. Norris; and these, I believe, until now, are the only local captures.

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* Trans. N.Z. Inst., vol. ix., p. 459. † Vol. xix., p. 37.

Art. XXX.—*Notes on the Entomology of Mount Holdsworth, Tararua Range.*

By G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 1st June,* 1904.]

During the middle of February of this year I spent, in company with my wife, a fortnight in the vicinity of Mount Holdsworth. The object of this and two previous expeditions undertaken by me was to investigate the insect fauna of this well-known range of mountains; and, although the results at present arrived at cannot be regarded as complete, it is perhaps desirable that they should be placed on record, more especially as, so far as I am aware, the Tararuas have not yet been visited by other entomologists.

The Tararua Range is, of course, very familiar to all residents in Wellington, its snow-capped summits, which close in the head of the Hutt Valley, being a most beautiful and conspicuous feature in the landscape in winter-time. These peaks constitute the southern portion of the range, and Mount Holdsworth, which is situated further to the north, is hidden by them. The range is best approached from the other side—*i.e.*, from the Wairarapa—and intending visitors should take the early train to either Carterton or Masterton, and thence proceed by trap to the junction of the Waingawa and Mangatariri Rivers. From this point there is a fair road for about four miles up the latter river, and a good camping-ground may be found at the termination of the road. To adequately explore the mountain it is necessary to make a permanent camp here, so that suitable weather may be selected for the ascent, as the summit of the mountain is nearly always enveloped in cloud. This is no doubt due to the fact that this range is situated in the centre of the southern portion of the North Island, and, being the highest land in the neighbourhood, attracts large quantities of cloud whenever there is the slightest atmospheric disturbance. In fact, much cloud is attracted with any wind, either north-west or south-east. For entomological or viewing purposes, the mountain should not be attempted except during the passage of the crest of an anti-cyclone—*i.e.*, when the barometer is at its highest at the termination of a southerly wind, before the change to the north-west, the sky being, of course, absolutely clear at the time.

I have dwelt at some length on the meteorological aspect of the question, as it is a most important one. In fact, on two previous visits which I made to this locality, both a week in duration, I was unable to ascend the mountain, and the expeditions were almost fruitless in result, owing to unfavourable weather conditions,

although at the time the weather in other places would have been fairly satisfactory for entomological work.

From the above-described camping-ground at the end of the road, the top of the mountain may be reached after about six hours' hard climbing. The time and labour now necessary could, however, be reduced by at least one-half were a satisfactory track made through the bush, and this could no doubt be done for a very small sum. In the interests of botanists, entomologists, and others, it is surely possible that something may be done in this direction, when the exceptionally fine view which may be obtained from this mountain, its extreme richness in alpine plants, and its proximity to Wellington are all taken into account. Some steps ought to be taken to render such an interesting locality more readily accessible, and, in default of other means, a portion of the Research Fund of this Society might perhaps be so employed in thus aiding original biological research in the wilds of New Zealand.

The ascent of the mountain is not severe, the sole difficulty in the undertaking being due to the dense bush and undergrowth. There have been bush-fires from time to time at several points on the track, which have greatly increased this difficulty, and it is in these places that the track is so extremely difficult to follow. These fires in forest reserves, such as this, are much to be regretted, and any persons lighting such fires ought to be very severely punished. The land here is quite unsuitable for settlement, and hence the ranges have, I understand, been very wisely set aside as a forest reserve. The reserve is reached about one mile beyond the termination of the road, and at this point the Mangatariri River has to be forded. This is easily accomplished in fine weather, and, whilst fording, a beautiful view of a primeval forest stream of the purest water may be obtained. The track continues alongside the stream through very fine forest for about another mile, when an ascent of about 1,000 ft. brings us to what is called the "lower camp," which is situated in the midst of wrecked bush, the site of what has evidently been one of the most disastrous fires on Mount Holdsworth. After this is passed the track passes for another mile through subalpine bush, 2,500 ft. There is a beautiful carpet of native grasses, and the trees are profusely festooned with long pendant mosses. For the next mile or so the track descends about 300 ft., traversing a broad swampy spur covered with low brushwood, chiefly manuka and birch. The vegetation is, however, largely subalpine, the mountain kiki and many grasses and mosses being frequently met with. At the end of this spur the "upper camp" is reached, which is situated at an elevation of about 2,300 ft., and is at the foot of the steep spur which leads to the summit of the mountain.

After this the track is very steep, and at about 3,800 ft. the birch-trees, which have become, as usual, very gnarled and stunted and thickly covered with lichens and mosses, suddenly end, and the open grassy country of the high mountain is reached, this elevation apparently representing the usual line of permanent snow.

I have seldom seen a mountain so richly covered with alpine plants as Mount Holdsworth, and I feel satisfied that it would be a locality of extreme interest to a botanist. Amongst many others, I observed the following familiar plants in great profusion: Mountain-lily (*Ranunculus insignis ?*), spear-grass (*Aciphylla squarrosa* and *A. colensoi* or allied species), various species of *Celmisia*, &c. The only introduced plant I noticed was the "cape-weed" (*Hypochæris*), which was in profusion at about 4,000 ft. The exceptionally efficient means of dispersal with which its seeds are endowed no doubt explains its appearance so high on the mountain.

From the bush-line to the top of the mountain the distance is about three miles, and the ascent is very easy. The view obtained from the top is very fine, embracing Mount Egmont to the north-west, the Island of Kapiti, the Straits, and a considerable part of the northern portion of the South Island, including Mount Tapuaenuku, to the west, the opposite side of the ranges which close in the head of the Hutt Valley could be recognised to the south, and the long, low ranges of hills on the east coast, and beyond these the ocean could clearly be seen.

During my visit I made two successful ascents of Mount Holdsworth. On one occasion the weather was absolutely perfect, on the other somewhat cloudy and too cool for many insects to be about. It was, however, evident that I was too late in the season for many of the high alpine species, so that further visits are necessary earlier in the year, and the second week in January would probably be about the best time to find the greatest number of species.

I specially looked out for the two mountain butterflies, *Erebia pluto* and *Erebia butleri*, but could see nothing of them, and feel sure that, had they been present, some specimens would have been in evidence. I should mention, in support of this contention, that these butterflies are found as late as the middle of March on the mountains in the South Island, where they occur. I was not, however, altogether surprised at the absence of these insects, as they have never yet been recorded from the North Island. The same remarks apply to *Argyrophenga antipodum*, which is exclusively an alpine butterfly in the provinces of Nelson and Marlborough, but is found abundantly elsewhere in the South Island, both on mountains and in tussock country.

I was, however, much more surprised in not finding any species of *Crambus* or *Orocrambus* on Mount Holdsworth, and do not think that the total absence of both these genera, which are characteristic of all the mountains I have ever visited in the South Island, can be explained by the lateness of the season, though future visits must definitely determine this. In connection with the distribution of these forms, it would be interesting to know whether geologists have yet determined the northern limit of general glaciation in New Zealand. The absence of these characteristic alpine insects from the Tararuas may perhaps have some bearing on this question, as without the glaciation of the intervening lowlands such species might not have been able to travel from the mountains of the South Island to those of the North Island. The Tararua Range is an important one in connection with this inquiry, as it is the nearest high mountain-range to the South Island.

I will now give a list of the more interesting species observed on Mount Holdsworth and in its neighbourhood, with some special remarks on the rarer species met with. It must, however, be clearly understood that this list does not claim to be an exhaustive one, but subject to revision when the locality has been more adequately worked by entomologists.

LEPIDOPTERA.

Vanessa gonerilla.

This butterfly was very abundant on Mount Holdsworth, from the bush-line to the summit. The specimens were very large, and in perfect condition. They, however, exhibited no divergence from the usual type.

Chrysophanus salustius.

A few specimens seen in the Mangatariri Valley.

C. boldenarum.

A distinct variety of this insect occurs in river-beds on the Wairarapa Plain.

Lycæna phœbe.

Mangatariri River; sparingly.

Nyctemera annulata.

Two specimens of this very common insect occurred on Mount Holdsworth at 4,000 ft. Had they not been actually netted, they might readily have been mistaken for one of the *Erebias*, and reported as such.

Leucania griseipennis.

At "sugar," Mangatariri River. Rare.

L. purdii.

At "sugar," Mangatariri River. Three specimens only.

L. atristriga.
At "sugar," Mangatariri River. Extremely abundant.

L. unipuncta.
At "sugar," Mangatariri River. Rare.

Melanchra insignis.
At "sugar," Mangatariri River. Rare.

M. plena.
At "sugar," Mangatariri River. Three specimens only. Not quite typical.

M. vitiosa.
At "sugar," Mangatariri River. One only.

M. composita.
At "sugar," Mangatariri River. Not so common as usual.

M. ustistriga.
At "sugar," Mangatariri River. A few only.

M. lignana.
At "sugar," Mangatariri River. Common.

Bityla defigurata.
At "sugar," Mangatariri River. One only.

Cosmodes elegans.
One superb specimen, amongst grass near camp. I have not taken this species previously.

Tatosoma agrionata.
One specimen, in forest. Probably too late for this insect.

T. lestevata.
I secured a magnificent female specimen of this extremely rare species at "sugar" on 26th February; my other two specimens, both males, were taken, one at Nelson in 1885, and one at Wainuiomata in 1887. There are two specimens in the collection of the late Mr. R. W. Fereday, now in the Christchurch Museum. I am not aware of any others.

Elvia glaucata.
One specimen, in forest. Passed.

Hydriomena subochraria.
Very common in the Mangatariri Valley. This species is characteristic of the locality, as it is not a generally common species.

Asthena pulchraria.
In forest. A few specimens. Passed.

A. schistaria.
In forest. A few specimens. Passed.

Venusia undosata.
One specimen seen. Passed.

Asaphodes megaspilata.
Common as usual.

Xanthorhoe semifissata.
A few seen. Passed.

X. clarata.
Two specimens taken on Mount Holdsworth at 4,000 ft. Passed.

X. beata.
In forest. Passed.

X. ægrota.
One specimen only. Mangatariri River.

X. cinerearia.
Common as usual.

Dasyuris partheniata.
This fine and conspicuous insect was very abundant on Mount Holdsworth from 3,800 ft. to 5,000 ft.

Notoreas mechanitis.
Several taken on Mount Holdsworth at about 4,500 ft.

N. paradelpha.
Several taken on Mount Holdsworth at about 4,500 ft.

N. omichlias.
Extremely abundant on Mount Holdsworth from 3,800 ft. to 5,000 ft. This was much the commonest insect seen. It is a rare species on the mountains in the South Island.

N. brephos.
Some very small and vividly marked specimens were captured by Mrs. Hudson, in the river-bed of the Mangatariri.

Epirranthis alectoraria.
One specimen, at "sugar."

Leptomeris rubraria.
Common as usual. Mangatariri River.

Selidosema fenerata.
Common as usual. Mangatariri River.

S. rudiata.
Common as usual. Mangatariri River.

S. suavis.
Common as usual. Mangatariri River.

S. productata.
Common as usual. Mangatariri River, and in birch forest up to 3,000 ft. A white variety of the female taken at "sugar."

S. melinata.
Common as usual. Mangatariri Valley.

S. panagrata.
Common as usual. Mangatariri Valley.

S. dejectaria.
Common as usual. Mangatariri Valley.

Sestra humeraria.
Common in forest as usual.

Gonophylla fortinata.
One specimen, in forest.

Declana floccosa.
Common as usual.

Crambus ramosellus.
Common as usual. Mangatariri and Waingawa Rivers.

C. flexuosellus.
Common as usual. Mangatariri and Waingawa Rivers.

C. vitellus.
Common as usual. Mangatariri and Waingawa Rivers.

C. apicellus.
On swampy spur on track to Mount Holdsworth. Common.

C. xanthogrammus.
One specimen taken by Mrs. Hudson, Mangatariri River.

Mecyna marmarina.
A large pale variety of this species was common on Mount Holdsworth from about 3,800 ft. to 4,500 ft.

M. flavidalis.
Common as usual.

Scoparia philerga.
A few worn specimens in forest.

S. acharis.
A few worn specimens in forest.

S. hemicycla.
In stunted birch forest, Mount Holdsworth, 3,600 ft., common, but rather worn; evidently too late for it. This is a rare and interesting species.

S. characta.
One specimen seen at "sugar," Mangatariri River.

S. epicomia.
In forest, Mangatariri River.

S. feredayi.
In forest, Mangatariri River. A few only, in poor condition.

S. crypsinoa.
Mount Holdsworth, 4,000 ft. Worn.

S. sabulosella.
Common as usual. Mangatariri River.

S. steropæa.
One seen. Mangatariri River.

S. astragolota ?
Mount Holdsworth, in forest, 3,500 ft.

S. asterisca.
At "sugar," Mangatariri River.

Nesarcha hybreadalis.
One seen. Mangatariri River.

Musotima aduncalis.
Common as usual. Mangatariri River.

Platyptilia haasti.
On swampy spur track to Mount Holdsworth. Locally common.

Pterophorus lycosemus.
Common in forest, Mangatariri River.

P. monospilalis.
Common in forest, Mangatariri River.

Clepsicosma iridia.
I took two specimens of this species in the dense swampy forest near the Mangatariri River.

Capua semiferana and *Noteraula straminea.*
Taken commonly by Mrs. Hudson amongst tutu, Mangatariri River.

Adoxophyes conditana.
In forest, Mangatariri River.

Simaethis.
Three specimens of this interesting genus occurred on Mount Holdsworth, from 3,600 ft. to 4,000 ft., as usual. These insects were flying very rapidly in the hottest sunshine.

Neuroptera.

The following species of *Neuroptera* were observed. The season was, however, too far advanced for these insects, and a visit earlier in the year would no doubt yield better results. The four common species of dragon-flies were abundant—*i.e.*, *Uropetala carovei*, *Somatochlora smithii*, *Lestes colensonis*, and *Xanthagrion zealandicum*.

Stenosmylus latiusculus.

I secured seven specimens of this very rare insect at "sugar" in the Mangatariri Valley. They usually appeared singly each night, but the last night I was at the camp I secured four, two of them arriving at the "sugar" after 9 p.m. This species was described by Mr. McLachlan in 1894 from two specimens, one taken at Waitara and the other at Greymouth. I captured my first specimen in the Orongaronga Valley, to the east of Wellington Harbour, in January, 1892, and have not since met with the insect until this year. So far as I am aware, the above include all the captures which have been made.

Œconesus maori.

One specimen, at "sugar," Mangatariri River.

Polycentropus puerilis.

At light, camp Mangatariri River.

Oniscigaster ——— sp. ?

One nymph taken in river in January, 1902.

Atelophlebia.

Several species observed.

Coleoptera.

This order was only worked in a desultory manner.

Mecodema scitulum.

Several specimens taken under stones on lower spurs of Mount Holdsworth, January, 1902. The forest at the foot of the mountain appears poor in beetles, but half an hour's beating yielded a fine anthribid.

Orthoptera.

Two or three fine species of grasshoppers occurred on Mount Holdsworth at elevations of 3,800 ft. to 5,000 ft., and an interesting stick insect on manuka-bushes at the "lower camp" (2,000 ft.), none of which have yet been determined.

ART. XXXI.—Epalxiphora axenana, *Meyr.: a Species of* Lepidoptera *scarce in New Zealand.*

By AMBROSE QUAIL, F.E.S. (London).

[*Read before the Wellington Philosophical Society, 1st June,* 1904.]

Plate XXI.

THIS species of *Lepidoptera* I found of considerable interest. It occurs throughout New Zealand from early summer to winter, but seems to be scarce everywhere, though its relative scarcity probably depends to some extent upon climatic conditions. During the summer of 1901–2 sunshine was continuous throughout, and *Epalxiphora axenana* occurred in considerable numbers in the strip of sparsely wooded bush reserve where I had previously taken the species but sparingly. I do not know where the males rest, but have beaten them from brown dry leaves of tree-ferns, and also from the green leaves of the food-plant. I do not remember to have ever seen a male resting in an exposed situation; the females, however, rest exposed on the upper side of a leaf of *Piper excelsum* (its food-plant), where the coloration is rather conspicuous, but the shape of the insect with its wings closed is not mothlike—*i.e.*, not conspicuously so. The position taken up by the females is not accidentally due to the drying of the wings on emergence from the pupa, which takes place during the afternoon. The insect flies at dusk, whereas my specimens have always been taken during the forenoon, and from two so taken I procured ova which were fertile, proving the insects had been flying the previous night.

Mr. Meyrick has twice published his diagnoses of the genus *Epalxiphora.** His description of the species was made from a single ♂ specimen taken off a tree-trunk in Wellington, New Zealand. The sexual dimorphism of the species makes descriptions of the ♀ ♀ a necessity. The costa of anterior wings is in males curved, in females elbowed; the anterior-wing markings differ between the sexes: ♂ pattern is divided into basal and outer areas, with a characteristic buff apical tip; ♀ pattern is composed of transverse and longitudinal markings usually, but this sex is very variable. A bright-orange basal streak on costa of posterior wings ♂ (covered by anterior wings) is not present in ♀. The only mark of anterior wings which appears to be present in both sexes is a crescentic or angular mark about the middle of the inner margin, which, when the wings are closed together edge to edge over the back, forms a characteristic ocellated spot.

* Meyr., Proc. Linn. Soc. N.S.W., 1881, 648; Trans. N.Z. Inst., xvii., 147.

Epalxiphora axenana. Fig. 8.

25 mm. Forelegs dark-fuscous, ringed ochreous at joints; head above fuscous mixed with grey; thorax dark or light fuscous, tufts pitchy. Abdomen ochreous (anal segments testaceous) or wholly yellowish-grey. Anterior wings curved from base, apex falcate, outer margin obliquely sinuate. Basal area grey broadly mixed with dark fuscous dots to ⅓ costa, whence edged with indefinite dark fuscous transverse line to middle of wing, then with inner tooth and outward curve to ½ inner margin it includes the marginal lunar mark, which is completed by a faint curve and dot; towards the inner margin the basal area shades to brownish-grey. Outer area dark-fuscous towards costa, reddish-brown or delicate violet hue towards inner margin; an elongate transverse costal spot of either colour at ½ runs into discal black line, sometimes dividing it into two angular spots, in front a yellow or buff tip obliquely elongates to apex. Cilia ochreous with dark fuscous bars and basal line. Posterior wings grey or lighter with dark posterior mottling, cilia white with very fine dark-grey basal line.

Six ♂ ♂, others not retained: except in ground-colour and presence or absence of the violet hue there is no variation.

Epalixiphora axenana, ♀. Fig. 1.

27–30 mm. Head and thorax usually of same colour as ground-colour of wings, tufts pitchy only when some of the wing-markings are so. Abdomen yellowish-white. Anterior wings: Costa elbowed at ⅓, thence slightly curved to apex, outer margin obliquely sinuate, apex falcate. Ground-colour very pale-yellowish (bone-colour), at base mixed with dark dots, near inner margin suffused with greenish-fuscous. At ⅓ costa a dark olive-green transverse elongate spot to discal cell, below is a paler spot, and an indefinite longitudinal line angulated or curved to inner margin. At ⅓ costa a transverse greenish fuscous spot curved outward unites with a patch of similar colour covering the whole anal area, extending from before middle of wing longitudinally with irregular outline to near apex, its transverse outline deeply broken by the ground-colour forming the curve of lunar mark at ½ inner margin. Nervures posteriorly thinly fuscous. A dilated sinuate costal streak of greenish-brown colour from ⅓ costa to near apex breaks the ground-colour into a longitudinal pattern. Cilia pale reddish-grey barred with fuscous. Posterior wings: Apex more acute than ♂, margin somewhat sinuate. Light-grey with posterior yellow tint, dark longitudinal mottling, cilia whitish, basal line fuscous.

I have selected this as the type form, it being the most abundant, though there is considerable colour-variation, chiefly as follows:—

α. Anterior wings: Ground-colour pale-yellow with greenish hue, markings pale-green, inner marginal lunar mark surrounded with dark-fuscous. Not common.

β. Anterior wings: Ground-colour reddish-yellow, markings ferruginous, the whole therefore having a reddish hue. Not common.

γ. Anterior wings: Ground-colour as type but less distinct on lower area, markings dark-fuscous without greenish hue, anal patch coppery-brown. A very handsome form; not common.

The following I prefer to term "aberrations" rather than "varieties," since one needs to breed from ova a larger proportion of any given form to term it a definite variety, otherwise subspecies.

Ab. albo-suffusa, n. ab. Fig. 2.

Anterior wings: Markings longitudinally divided from inner base to apex, the line of division deeply dentate at $\frac{2}{3}$; ground-colour white above, at $\frac{1}{3}$ costa a dark greenish brown elongate transverse spot; a very faint costal mark at $\frac{1}{2}$, costal streak at $\frac{2}{3}$ to near apex is fuscous mixed with lighter; lower half similar to type of markings; colour fuscous posteriorly dusted with white, nervures thinly marked, marginal lunar mark distinct. Some specimens are suffused with white over a larger area restricting the anal patch, the dark costal mark at $\frac{1}{3}$ normal; inner margin has thin fuscous basal streak to lunar mark wider beyond and shading to grey at outer margin. Some have inner colour coppery.

Ab. brunnei-lineata, n. ab. Fig. 3.

Anterior wings: Dark fuscous streak extends from base to below apex, with a parallel line above it of reddish-yellow ground-colour heightening the linear effect, being suffused with fuscous on costa, with normal fuscous costal marks; below the colour is suffused with dark-fuscous from base to lunar mark and beyond. Posterior wings grey, with posterior reddish hue. One specimen

Ab. purpurascens, n. ab. Fig. 4.

Anterior wings: Pattern composed of two colours separated by an almost straight dividing-line from base to near apex; costal area is unicolorous, pale-yellow (bone-colour), costal marks faintly dusted in grey; lower area is purplish-red, marginal lunar mark scarcely perceptible. Cilia reddish-yellow. A specimen has pale fuscous costal marks, lower area of wing deep-purplish-black with some indistinct markings. Rare; three specimens.

Ab. **obsoleta**, n. ab. Fig. 5.

Anterior wings: Ground-colour pale-yellow with an orange suffusion at base, longitudinally and posteriorly; no other markings. One specimen.

Ab. **obscura**, n. ab. Fig. 6.

Anterior wings wholly covered with fine sheeny dark-fuscous dots obscuring all markings except faint costal marks at $\frac{1}{3}$ and $\frac{1}{2}$, and faint lunar mark; apex of anterior wings tipped pitchy; thoracic tufts pitchy. One specimen.

Ab. **nigra-extrema**, n. ab. Fig. 7.

Anterior wings black, costal area to $\frac{1}{3}$ light-fuscous with black dots, and spot at $\frac{1}{3}$; fuscous mottling at $\frac{2}{3}$ in middle of wing, similar mottling from lunar mark to anal angle. Several specimens, one having purplish-red ground-colour instead of black.

The female deposits a circular semitransparent mass numbering some twenty-nine ova, symmetrically imbricated, closely appressed. If laid on a green leaf, reflection of the natural tint of the leaf through the ova must afford greater protection than any colour of the egg-shell could do. Ova deposited 22nd January, 1902, hatched 5th February = 14 days. Ova deposited 20th February, 1903, hatched 5th March = 13 days.

Ovum (figs. 9, 10, 11): Each ovum is oval in outline, slightly convex above and covered with a rather large crystalline pattern composed mostly of pentagonal but some hexagonal figures. Examined some hours after they were deposited each ovum had inner and outer circumferences, the pale-greenish egg-contents not reaching the outer wall of the ovum; the micropyle, forming a rosette of small elongate figures, is situated towards one end of the ovum on this rather wide marginal area. The ovum is always so placed in relation to the egg-mass that the micropyle is outwards and not covered by other ova. The first ovum laid forms the centre of the egg-mass to the disadvantage of the ensuing larva, which may—as it did in one instance—fail to eat through the overlapping edges of surrounding ova.

For two days the ovum contained only yelk spherules and the protoplasmic fluid whence the embryo ultimately develops: no cellular activity was observed.

In seven days the embryo reached an advanced stage, having formed, though neither caput nor thoracic segments could be detected, and at the head area, towards the micropyle, a large quantity of outer (greenish) spherules remained; the ocelli of the caput were distinct, the thoracic legs exceedingly long, out-

line of the abdominal segments quite distinct, abdominal feet and claspers well developed, even the anal comb could be distinguished; the outer spherules about these parts were almost used up. The number of developing embryos within the egg-mass reminds one of a dish of opened oysters. Two days later internal anatomy was well formed, and all external tubercle setæ and the jaws of caput becoming chitmous.

On the eleventh day the caput was very distinct, assuming at first a faint violet hue which gradually darkened to brown, the jaws appearing bright-reddish; spherules immediately in front of caput were not quite used up. No movement of jaws, but internal pulsation was observed. The larva does not emerge through the micropylar area.

The newly hatched larva does not eat the egg-shell. Young larvæ feed on the under-surface of a leaf beneath a few threads of silk; later two leaves are drawn together, or, failing this, the leaf is folded over. *Piper excelsum* is the staple pabulum of *Epalx. axenana:* the leaves are broad and succulent. In normal seasons it is difficult to find leaves of *P. excelsum* which are not riddled with holes: one suspects these are made by slugs. The larvæ of *Epalx. axenana* are easily alarmed and drop to the ground; they are seldom found feeding between leaves which have holes in them: the slugs or whatever cause the holes are probably responsible for a high mortality among them by alarming them away from their food. During the genial season referred to very few leaves of *P. excelsum* had holes in them (it was a very dry season), and the larvæ were plentiful on that plant, and on several other plants and shrubs on which I never found them at any other time.

The larva (figs. 12, 13, 14) when newly hatched has a very dark-brown head, otherwise it is transparent pale-greenish. The head is flat-elongate, and the mouth parts protrude forwards; tapering somewhat anteriorly and posteriorly, abdominal segments 1 to 3 are widest, and the 9th narrowest. The whole skin is covered with long spicules; all setæ are smooth. Prothorax has no scutellum; on either side of medio-dorsal line are three setæ anterior marginal and three setæ posterior semimarginal, all equidistant. Posterior spiracle circular, prespiracular tubercle bears three setæ, tubercle above legs two setæ. Abdominal segments: Trapezoidals normal, i. seta short, ii. seta longer, supraspiracular single long seta, spiracle circular placed on a mid-lateral swelling, the subspiracular is anterior and higher than the post-subspiracular tubercle, single seta each, basal tubercle bears two setæ. Abdominal feet have a single row of dark widely spaced hooklets, about twelve in number.

The larva in its second stage is very pale-greenish colour,

head yellowish with a suspicion of mottling. The mouth-parts are normal, not protruding as in previous stage; spinneret is short and stout. Prothorax as previous stage. Mesothorax: One below the other are two setæ in a dorsal depression, below which a large swelling bears two similar setæ, a lower posterior swelling bears one seta, an anterior swelling bears two setæ; tubercle above legs bears two setæ. Abdominal segments: All tubercles bear single seta, i. and ii. normal, iii. above the spiracle, which is well sunk into a lateral depression, anterior subspiracular almost below spiracle, post-subspiracular quite beneath, vi. anterior, basal setæ three in number. Abdominal feet have a single row of closely placed terminal hooks.

The adult larva is semitransparent green, with no appreciable markings except on the head, which is yellowish with characteristic brown mottling on each lobe. External structure as in second stage.

The length of a larva at fifteen days is 10 mm., after which it grows rapidly; at thirty days it is 28 mm., remaining attenuated in breadth. Duration of larval existence, thirty to thirty-two days.

The skin has a reticulation. From the centre of each figure—hexagonal or what not—of which it is composed a small boss rises tipped with a spike: these spicules persist throughout the larval existence, and practically cover the whole skin; but around the base of setæ a space exists without the spicules. The anal comb is seen with difficulty in a newly hatched larva, when the prongs are like setæ. In an adult larva (figs. 15 and 16) the comb consists of eight strong prongs each terminating in two points; at either side are incipient prongs. The prongs rise from a small pad on the underside of anal flap. Judging from the direction of the prongs in different specimens examined, the comb may be elevated or lowered at will. The function of the comb is probably in connection with the removal of excrement, and the position of comb is best seen when the anal flap is distended at the passing of same. Spicules are numerous in the region of the comb.

I once found three pupæ each in a leaf of *Urtica ferox* (tree-nettle). These leaves are covered with stinging spines, and had been rolled into a cylinder. It is doubtful whether the larvæ fed on the *Urtica* leaves.

The pupal shroud is made by the larva first with an outer series of silk threads apparently placed irregularly, but designed to hold together the two leaves or the fold of the leaf and prevent any alteration in the curvature which might subsequently affect the pupa disadvantageously. Within this outer series of threads a definite closely woven elongate cocoon is made,

having a slender neck which extends to the edge of leaf or leaves. The pupa is suspended horizontally within the body of the cocoon. In emergence the pupa projects rather more than the thoracic segments beyond the neck of the cocoon, a silken cable secured to its anal armature preventing it from overpassing the point of security and falling to the ground. I did find one pupa, which had either slipped its cable or broken it, with its anal armature amongst the outer silk at the mouth of the cocoon; the pupa, having passed quite out of the cocoon, was empty when found.

The pupa at first is unicolorous, green with darker green mediodorsal line on abdomen. The first colour-change is noticed in the eyes, which become red, then a reddish colour spreads over the face-parts, next the thorax and wings show imaginal markings. Duration of pupal stage, seventeen to twenty-nine days.

The pupa is 9 mm. long, 3 mm. wide at mesothorax, anterior end rounded; the segments taper dorsally and ventrally from mesothorax; the 9th abdominal is ventrally rounded, 10th produced to a long blunt point carrying two lateral hooks on each side, two ventro-posterior hooks, two posterior hooks—in all eight hooks, which are not the modified prongs of the larval anal comb, but a distinct pupal armature. Wing-cases extend to the posterior edge of 3rd abdominal segment; antennæ follow the costal curve from back of eyes to tips of wings; proboscis and two pairs of legs fill the space to antennal tips. Abdominals 2 to 7 carry two rows of dorsal spines. Some portions of the segments have a reticulation similar to that on the larval skin, but without bosses or spikes except in the region of the obsolete anal orifice, where a minute point appears in the centre of many figures of the reticulation.

On dehiscence the head separates and carries the antennæ, which are separated throughout their length from the other organs; leg-cases remain attached at their tips; wing-cases are loosened at their suture with abdomen. The dorsum of thorax splits centrally.

The imagines of first brood were all males with one exception, a ♀ type like its parent. Imagines of second brood were mostly males, but there were two typical females, and one like the parent, type form *β*.

Parasites on *Epalx. axenana*: Frequently the one true home of the larva of *Epalx. axenana* is occupied by a spider; sometimes a living larva and a living but very small, possibly juvenile, spider have occupied the same roof-leaf, and pupæ have been similarly situated. Sometimes the pupa contains the grub of a parasite which assimilates the internal anatomy

of its host, and emerges from the head of the pupa-case a fly—an *Ichneumon, Triclistus*, Forst., sp. nov., of which Mr. Claude Morley says, "certainly very closely allied to *Trilistus nigritellus*, Holmyr., from which it differs mainly in its unicolorous antennæ, dark tegutæ, black hind tibiæ, and larger size."

EXPLANATION OF PLATE XXI.

Fig. 1. *Epalxiphora axenana*, ♀ type (nat. size).
Fig. 2. ,, ♀ *Albo-suffusa*, n. ab. (nat. size).
Fig. 3. ,, ♀ *Brunnei-lineata*, n. ab.
Fig. 4. ,, ♀ *Purpurascens*, n. ab.
Fig. 5. ,, ♀ *Obsoleta*, n. ab.
Fig. 6. ,, ♀ *Obscura*, n. ab.
Fig. 7. ,, ♀ *Nigra-extrema*, n. ab.
Fig. 8. ,, ♂ type.
Fig. 9. Ova, imbrication, and ovum at two days (×75).
Fig. 10. Ovum at seven days (×75).
Fig. 11. Micropyle, and sculpturing of ovum (×250).
Fig. 12. First larval stage, dorsa of posterior segments (×250).
Fig. 13. ,, dorsum of caput (×250).
Fig. 14. ,, 3rd abdominal segment, lateral view (×250).
Fig. 15. Second larval stage, anal comb, anal flap distended (×250).
Fig. 16. Ultimate stage, anal comb, ventral view (×50).

Art. XXXII.—*On the Occurrence of* Graucalus melanops, *Latham, in New Zealand.*

By Captain Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 2nd November, 1904.*]

On the 11th June last the Museum received a specimen in the flesh of the shrike-thrush from Mr. E. A. Radford, of Gebbie's Valley, who stated that he had picked it up dead on Rabbit Island. The bird is in the young plumage, and proved to be a male.

The first recorded occurrence of the species in New Zealand was a specimen in the Nelson Athenæum, which had been shot in an apple-tree at Motueka in 1869 or 1870. Another specimen was shot near Invercargill on the 8th April, 1870. Both were in the immature plumage. I was also informed by the Hon. W. Mantell that he had seen one at Port Chalmers in 1842. Mr. W. T. L. Travers also told me that he had seen the bird at his run at Lake Guyon, and Captain Fraser told me that he had seen it at Lake Hawea. In all these instances the birds appear to have been in immature plumage also. This seems very remarkable.

Graucalus melanops.

G. melanops, Vigors and Horsford; Buller, "Birds of New Zealand," 1st ed. p. 148, 2nd ed. vol. i. p. 66; Cat. Birds in British Museum, vol. iv., p. 30. *Colluricincla concinna*, Hutton, Cat. Birds of New Zealand, p. 15 (1871).

Light ash-grey; abdomen and lower tail-coverts white; a broad band of black from the bill through the eye. The two middle tail-feathers dark-grey, lateral ones brownish-black, tipped with white. Quills brownish-black, the outer webs edged with white. Bill and legs black. Length of the wing, 8 in.; of the tarsus, 1·1 in. In the adult bird the forehead, sides of the face and neck, the throat and fore-neck, are black, with a greenish gloss.

The immature bird from Australia is described as having wavy bars of dusky black on the throat, but there are none on any of the three New Zealand examples which I have seen.

ART. XXXIII.—*A Rare Saurian.*

By Archdeacon WALSH.

[*Read before the Auckland Institute, 12th September, 1904.*]

FROM time to time over a number of years reports have been brought in by surveyors, bushmen, and others of the existence of a large lizard on the Waoku Plateau. This is an extensive tableland, about 2,000 ft. above sea-level, lying between the Hokianga and Kaipara districts. It is covered with forest, and here and there are several shallow lagoons. It is about these lagoons that the lizard is supposed to make its home.

So far as I am aware, no specimens have been captured; or, if they have, they have not been preserved. A dead specimen was, however, washed down the Waima Creek, a stream leading from the plateau, about thirty-five years ago, on the occasion of the *hahunga* or official reinterment of the bones of Arama Karaka, when it was seen by several European visitors, and was recognised by the Maoris, who were much frightened at its appearance. Being in a partly decomposed condition, however, no attempt, I believe, was made at preservation. From the appearance of this specimen, and from such other slight details as have been gathered from the reports above mentioned, it has been concluded, I understand, that the animal is a species of salamander hitherto undescribed.

As I have occasional opportunities of visiting the neighbourhood of the Waoku Plateau, as well as the Waima Valley, where the decomposed specimen was seen, I have made it my business to seek for any information that was to be had on the subject.

Beyond the repetition of certain vague second-hand rumours, however, I had until lately never met with any success. The lizard, like the *taniwha*, was apparently a creature of whom all had heard but none had seen, and if it had not been for the well-authenticated specimen of Waima I should have been tempted to classify it amongst the fabled monsters of imagination.

During a recent visit to Hokianga, however, in the course of a conversation with Mr. John Webster, of Opononi, the ultimate referee in all Hokianga matters, this gentleman informed me that shortly after his coming to the district, some fifty years ago, he had seen an animal which may have been one of the sought-for species. He was exploring in a rocky part of the Wairiri Creek —a tributary of the Hokianga River—when he saw what he described as a lizard about 18 in. long of a yellowish colour. While looking about for a stick or stone wherewith to despatch it the reptile slipped down into the water, and quickly disappeared amongst the boulders in the bottom of the stream. Whether it was one of the same species there is not sufficient evidence for exact proof, but we have at least the fact established of a lizard of about the required dimensions, of amphibious habits, and found in a locality connected with the Waoku Plateau by a continuous forest. In the absence of any proof to the contrary, therefore, I think it may be fairly assumed that the species are identical, and that at that period at least the animal was pretty widely distributed.

My object in presenting these very sketchy notes is the hope that the information, scanty as it is, may lead to further research. Although a road has been made over the plateau, the place is still very much in its primitive condition. Some attempt at occupation was made some ten or fifteen years ago, but though a good deal of bush was cut down no very effective settlement took place. The swampy nature of the soil, which is nothing but a thick layer of vegetable humus, and the too abundant rains, made a successful "burn" impracticable, and after some more or less futile efforts to clear the land the attempt at settlement was generally abandoned. The clearings are fast reverting to bush, and the primæval forest which still occupies the greatest part of the surface remains practically intact. If, as seems to be the case, the animal is amphibious and probably a tree-climber, these qualities should help to secure it from the ravages of the wild pig, which would otherwise have probably exterminated it before this, as they have done in the case of the tuatara wherever they have had access.

Taking all things into consideration, therefore, I think there is little doubt that a careful and intelligent search would result in the addition of an interesting species to the list of the New Zealand fauna.

ART. XXXIV.—*A Revision of the Species of the* Formicidæ *(Ants) of New Zealand.*

By Professor Dr. A. FOREL.

Communicated by A. HAMILTON.

[*Read before the Wellington Philosophical Society, 1st June,* 1904.]

Chigny près Morges,
Switzerland, 3rd April, 1904.

DEAR SIR,—I have received the list of the *Hymenoptera* of New Zealand by P. Cameron, published in your Transactions, vol. xxxv., pp. 290–299. This list contains such a large number of errors that I think it necessary to send you a revision of the New Zealand species of *Formicidæ*, as now known. Of the species named in the list *Aphænogaster antarcticus*, Smith = *Monomorium antarcticum*, White, Smith named it *Atta antarctica*, while Cameron made an *Aphænogaster* of this false *Atta*—the *Aphænogaster* being more erroneous than the *Atta*. In the following paper I have given the necessary synonymy.

Mr. Cameron has forgotten to include in his list many new species discovered since 1892, and has added species that do not exist. He gives no *Lasius* in New Zealand, and *Formica zealandia* = *Melophorus advena*, Smith. Emery suggested that my *Strumigenys antarctica* may be a synonym of *Orectognathus perplexus*, Smith, because he thinks Smith has miscounted the number of joints of the antennæ; but, as it is only a suspicion, it must wait for more material.

I have no doubt that the North Island will furnish further new species after careful search, especially in vegetable mould and the hollows of trees.—Truly yours,

Prof. Dr. FOREL.

REVISION OF NEW ZEALAND SPECIES OF FORMICIDÆ.

1. Subfamily PONERINÆ, Lep., 1836.

PONERA, Latr., 1804.

(1.) P. (MESOPONERA) CASTANEA, Mayr., Reise "Novara," Zool. ii., 1, Formicidæ, 1865.
P. castanea, Smith, Trans. Ent. Soc. Lond., 1876, p. 489.
P. castaneicolor, Dalla Torre Cat., 1893, p. 38.

(2.) P. ANTIPODA, Forel, Ann. Soc. Ent. Belg., 1895.

ECTATOMMA, Smith, Cat., 1858.

(3.) E. (ACANTHOPONERA) BROUNII, Forel, Mitt. Schw. Ent. Ges., 1892, p. 330.

DISCOTHYREA, Roger, Berlin, Ent. Ges., 1863.

(4.) D. ANTARCTICA, Emery, Trans. N.Z. Inst., 1895, p. 635.

AMBLYOPONE, Erichson, Arch. f. Natg., 1841.

(5.) A. CEPHALOTES, Smith, Trans. Ent. Soc. London, 1876, p. 490.

(6.) A. SAUNDERSI, Forel, Mitt. Schw. Ent. Ges., 1892, p. 336.

2. Subfamily MYRMICINÆ, Lep., 1836 (p. 169).

ORECTOGNATHUS, Smith, 1854.

(7.) O. ANTENNATUS, Smith, Trans. Ent. Soc. London, 1854, p. 228.

(8.) O. PERPLEXUS, Smith, Trans. Ent. Soc. London, 1876, p. 491.

STRUMIGENYS, Smith, 1860 (p. 72).

(9.) S. ANTARCTICA, Forel, Mitt. Schw. Ent. Ges., 1892, p. 338.

HUBERIA, Forel, Ann. Soc. Belg., 1890.

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(12.) H. STRIATA, var. RUFESCENS, Forel, Revue Suisse de Zool., 1902, p. 447.

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(17.) M. INTEGRUM, Forel, Ann. Soc. Ent. Belg., 1894, p. 228.

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(19.) M. ADVENA, Smith.

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SUMMA.—Twenty forms (nineteen species and one variety).

ART XXXV.—*On some New Species of* Macro-lepidoptera *in New Zealand.*

By G. V. HUDSON, F.E.S.

[*Read before the Wellington Philosophical Society, 2nd November,* 1904.]

Plate XXII.

CARADRININA.

Orthosia pallida, n. sp.

Two specimens of this insect were taken by Mr. H. W. Simmonds at Napier in April, 1903.

The expansion of the wings is nearly 1½ in. *The fore wings are pale-cream colour*; there is a very obscure wavy grey transverse line near the base, another at about ⅓, and another at about ⅔, the space between the second and third lines being slightly shaded with brown. *The hind wings are almost white, slightly shaded with grey near the termen.* The head and thorax are cream-colour, and the abdomen whitish-ochreous.

This is an obscure species, and may perhaps ultimately prove to be a bleached or pale variety of some other species already described. Mr. Simmonds, however, assures me that he has no reason to doubt his specimens represent a distinct species.

* A cosmopolitan species (transported by ship).

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ill-defined wavy black stripe near the base, another at about ½; this is followed by a large central clear space containing a conspicuous discal spot above middle. There is a conspicuous very jagged black stripe from a little more than ½ of costa to about ¾ of dorsum, followed by a very conspicuous pale-ochreous line; beyond this are two somewhat ill-defined black bands. The cilia are black, mixed with pale bluish-green. *The hind wings are ochreous tinged with reddish and speckled with black, especially towards the base and termen.* There is a conspicuous black discal spot and *a clear rather wavy yellowish band about ¾ from base to termen.* The cilia are blackish. Head and thorax black dotted with pale bluish-green; abdomen yellowish.

Mr. Lewis has favoured me with the following note relating to the transformations of this interesting new species. "The specimen was bred from a pupa found in a cleft of rock: a chamber had been formed by cementing moss-dust and silk together. From the fragments of caterpillar-skin remaining, I judge that the larva was one I had tried unsuccessfully to rear a few weeks ago, found feeding openly on lichen, remarkable for its fimbriated aspect, each segment being produced into irregular lobed processes at the edges—very protective amongst lichen."

Lythria fulva, n. sp. Plate XXII., fig. 3.

This species was captured by Mr. J. H. Lewis near Mount Ida, Central Otago, at about 3,500 ft. above the sea-level.

The expansion of the wings is ¾ in. *The fore wings are dull greyish-brown, greenish-tinged.* There is a wavy darker band near the base; a broad median band with a strong rounded projection towards the termen above middle; a dull-greenish band on termen preceded by a row of pale dots on veins, cilia grey with blackish bars. *The hind wings are dull reddish-ochreous. There are three very obscure blackish transverse lines.* The cilia are grey, faintly barred with darker.

This is a very distinct species. It may be at once distinguished from *L. euclidiata* by the absence of the conspicuous red, black, and yellow markings on the underside of the fore and hind wings.

Porina minos, n. sp. Plate XXII., fig. 5.

This species was discovered by Mr. J. H. Lewis at Ophir.

The expansion of the wings is 1⅛ in. The fore wings are dull yellowish-brown. There are two rather large white spots near the base, *a wavy irregular chain of white spots at about ⅛, an oblique chain of white spots from about ¾ of costa to ⅔ of termen. The outer chain has two spots between veins 7 and 8 and*

8 *and* 9. *The spots between veins* 6 *and* 7 *on both series are much elongated and almost touch each other, thus forming together an interrupted oblique white line on the upper portion of the wing.* There are four small white spots on the termen near the tornus. The hind wings are pale yellowish-brown. The head and thorax dark-brown and very hairy; abdomen paler.

This species is easily recognised by its small size.

EXPLANATION OF PLATE XXII.

Fig. 1. *Chærocampa celerio.* (See page 359.)
Fig. 2. *Dichromodes ida.*
Fig. 3. *Lythria fulva.*
Fig. 4. *Grammodes pulcherrima.*
Fig. 5. *Porina minos.*

ART. XXXVA.—*On* Macro-lepidoptera *observed during the Summer of 1903–4, including a Note on the Occurrence of a Hawk-moth new to New Zealand.*

By G. V. HUDSON, F.E.S.

[*Read before the Wellington Philosophical Society, 6th July, 1904.*]

Plate XXII.

Anosia erippus.

Mr. R. I. Kingsley records having seen this butterfly in his garden at Nelson on the 6th January, 1904.

Diadema bolina.

This butterfly, which is usually very rare in New Zealand, occurred in considerable numbers in various parts of the country during the past summer. The Rev. Alex. Doull, of Otahuhu, to whom I am indebted for the fine series of specimens exhibited this evening, informs me that during the end of February and beginning of March he saw no less than fifteen specimens, and succeeded in capturing seven on a flowering shrub (*Escallonia floribunda*) in his garden. The occurrence of *Diadema bolina* at Wanganui in March was reported by Mr. Ritchings Grant, and at Nelson by Mr. R. I. Kingsley, who stated that he had seen seven specimens, and heard of others.

Chrysophanus salustius.

I have noticed, since my garden at Karori has become more sheltered through the growth of trees, that this butterfly is much more abundant there than formerly. Last summer it was very common, and one warm night in January I discovered, by means of a lantern, no less than six individuals

asleep. The butterflies were simply perched on the outside foliage of a *macrocarpa* tree, and were quite readily seen, though the bright-yellow colouring of the closed wings suggested a faded leaf. This resemblance would, however, afford the insect very efficient protection whilst resting asleep amongst the foliage of many of the native shrubs, the faded leaves of which are, in many instances, yellow in colour. In such situations its destruction by nocturnal enemies would, no doubt, thus be largely obviated.

Sphinx convolvuli.

This insect is generally very irregular in its appearance. Last summer, however, it was reported by Mr. Grant as very plentiful at Wanganui, and by Messrs. F. G. Gibbs and R. I. Kingsley as abundant in the Nelson District.

Chærocampa celerio, Linn. Plate XXII., fig. 1.

Four specimens of this insect, which, so far as I am aware, has not been previously met with in New Zealand, were taken in Nelson last summer—one specimen, apparently the first, by Mr. Kingsley the week before Christmas, another by Mr. Frank Whitwell shortly afterwards, a third by Mr. Edward Mules on 24th February, and a fourth by Mr. Gibbs a few days later. The occurrence of this insect in New Zealand is of excessive interest, as prior to this discovery the family *Sphingidæ* was only represented in this country by a single, almost cosmopolitan, species, *i.e.*, *Sphinx convolvuli*. It will be interesting to see if the newcomer is permanently established, and collectors should be specially on the watch to detect further specimens.

The expansion of the wings is about 3 in. The fore wings are brownish-ochreous, with short black and silvery longitudinal lines, and a shining silvery wavy streak, divided by two fine brownish lines running from the base of the dorsum to the apex, below which are whitish longitudinal lines running along the dorsum. A little below the middle of the costa is a black spot in a pale ring. The hind wings are rose-colour, with the termen and a central streak broadly black. The intermediate rosy band is also divided by black veins. The larva is green or brown, with black eye-like markings on the fifth and sixth segments, with white pupils, and enclosed in slender yellow rings. The horn is slender and long and straight. The larva feeds on the vine." (Kirby.)

C. celerio occurs rarely in Britain south of the Caledonian Canal, and in the north of Ireland, but only as an occasional immigrant. It is a very widely distributed species, otherwise ranging through west, central, and southern Europe, south Asia, Africa, and Australia.

Selidosema rudiata.

An additional food-plant for the larva of this insect is the wharangi (*Brachyglottis repanda*). (See "New Zealand Moths and Butterflies," page 83.)

Gonophylla ophiopa.

The following is the life-history of this species: The egg is oval, flattened at one end, pale sea-green, covered with numerous very slight hexagonal depressions. It is highly polished, with a large oval depression on each side of its long axis. As the enclosed embryo develops, small irregular reddish-brown patches appear on the surface of the egg-shell.

The larva, which feeds on tree-ferns (*Dicksonia*), is, when full-grown, about 1¼ in. in length and of uniform thickness throughout. The general colour is pale rusty-brown with an obscure pale-brown dorsal line, stronger on the thorax and at the commencement of each segment. There are two similar obscure lateral lines. The head is yellow, thickly dotted with dull-red, and the entire larva is thickly dotted with dark-brown dots and clothed with pale-reddish hairs. There are several obscure marks near the spiracular region.

This larva is very sluggish and grows slowly. It probably emerges from the egg in the autumn, hibernates during the winter, and feeds from September till the middle or end of December. It then finally buries itself in the earth and changes into a pupa, the moth appearing a month or six weeks later. (See "New Zealand Moths and Butterflies," p. 98.)

Paradetis porphyrias.

I find that my report of the occurrence of this species at Wainuiomata, recorded in the "Transactions of the New Zealand Institute," vol. xxxii., p. 11, is erroneous, having been founded on a mistaken identification.

Chloroclystis antarctica.

The larva of this species, which feeds on the common *Veronica* in December, is, when full-grown, about ¾ in. in length, rather attenuated anteriorly, almost uniform, dark reddish-brown, darker on the sides. The head is reddish, and there are traces of several longitudinal lines in younger larvæ. Others are dull yellowish-brown, with the lines plainer and the prolegs pale-yellow; but as the larva is so extremely variable a detailed description hardly appears possible. The pupa is enclosed between two leaves of the *Veronica*, fastened together with silk. The moth emerges at the end of January. ("New Zealand Moths and Butterflies," p. 42.)

III.—BOTANY.

ART. XXXVI.—*Some Hitherto-unrecorded Plant-habitats.*

By L. COCKAYNE, Ph.D.

Communicated by A. H. Cockayne.

[*Read before the Wellington Philosophical Society, 2nd November, 1904.*]

IN what follows I am indebted to my friend Mr. D. Petrie, M.A., F.L.S., for the identification of the grasses, and for that of the *Carices* and *Uncinia* to my esteemed correspondent Pastor G. Kükenthal.

FILICES.

Gymnogramme pozoi, Kunze, var. **rutæfolia,** R. Br.*

Growing in crevices of steep rock-faces, in full sunshine, and exposed to the violent north-west wind, Lower Gorge of River Waimakariri, Upper Canterbury Plain.

Hymenophyllum rufescens, T. Kirk.

On steep stony ground in shade of forest, lower subalpine region, Kelly's Hill, Westland.

Notochlæna distans, R. Br.

(1.) On old stony bed of River Kowhai, Kaikoura Plain, Marlborough. (2.) On rock-face, in full sunshine, Lower Gorge of River Waimakariri, Upper Canterbury Plain.

ISOETEÆ.

Isoëtes alpina, T. Kirk.

On the gravelly bottom of Lake Letitia, near Mount White, and of the tarns on the ancient moraine at Lochinvar, lower mountain region of the Waimakariri district, northern Canterbury.

GRAMINEÆ.

Danthonia australis, Buchanan.

Growing in light sandy loam and thickly covering the ground of steep hill-side in shade. In places there is little else than this remarkable grass, but usually *Celmisia incana*, Hook. f., var. *petiolata*, T. Kirk, and *Cel. lyallii*, Hook. f., grow through it here and there; or there may be a few plants

* The plant referred to here is probably the form described by Potts as *G. alpina*.

of *Danthonia crassiuscula*, T. Kirk, as well. Source of Nigger Creek, in the Candlestick Mountains, northern Canterbury, at an altitude of about 1000 m.

Danthonia oreophila, Petrie.
Subalpine meadow, at source of Nigger Creek.

Poa pusilla, Berggren.
(1.) On rocky ground, Dog Island, Foveaux Strait. (2.) Common near the new road at base of Bluff Hill, Foveaux Strait.

Poa dipsacea, Petrie. "A small form."—D. P.
Head of Nigger Creek, in subalpine meadow.

Deschampsia novæ-zelandiæ, Petrie. "A very slender form."—D. P.
Growing in ground where water frequently lies for a considerable time, on terrace of River Poulter, near base of Peveril Peak.

Agropyrum enysii, T. Kirk.
Spur of Candlestick Range, near Lochinvar, northern Canterbury.

CYPERACEÆ.

Uncinia filiformis, Boott.
(1.) (Herb. L. Cockayne, No. 7804): This form, according to Kükenthal, is typical. Growing in interior of *Nothofagus cliffortioides* forest at the base of the Black Range, subalpine region near source of River Waimakariri. (2.) (Herb. L. Cockayne, No. 7864): In *Dacrydium-Nothofagus* forest, almost at sea-level, Pickersgill Harbour, Dusky Sound, west coast of Otago.

Uncinia riparia, R. Br., var. **laxiflora** (Petrie), Kük.
Open ground near tableland forest and also within the forest, Chatham Island. This plant is probably the *U. rupestris*, Raoul, of Buchanan's list,* and it is the plant mentioned in my paper on the vegetation of Chatham Island.†

Uncinia cæspitosa, Col.
(Herb. L. Cockayne, No. 7868): Chatham Island. The precise station is uncertain, but most likely it is interior of lowland forest.

Carex wakatipu, Petrie.
(1.) East face of Mount Torlesse, Canterbury; altitude, 1,500 m. (2.) Near summit of Mount Fyffe, Seaward Kaikoura Mountains, Marlborough.

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* Trans. N.Z. Inst., vol. vii., 1875.
† Trans. N.Z. Inst., vol. xxxiv., 1902, pp. 310–12, 313.

Carex comans, Berggren.

(1.) Wet ground near roadside, Diamond Lake, Otago. (2.) Near shore of Foveaux Strait, base of Bluff Hill, Southland. (3.) Meadow of Centre Island, Foveaux Strait; very common.

Carex comans, Bergg., var. **Cheesemanni** (Petrie), Kük.

Wet ground near Lake Brunner, Westland.

Carex petriei, Cheeseman, var. **suberostris,** Kük.

(Herb. L. Cockayne, 1531): Growing amongst moss in running water, Mount Earnslaw, Otago; altitude, 1,250 m.

Carex pseudocyperus, L.

In running water, valley of Little Kowhai, base of Mount Torlesse.

Carex darwinii, Boott, var. **urolepis** (Franch), Kük.

Lowland swamp near Lake Huro, Chatham Island. This plant has not been previously recorded for the New Zealand biological region, and forms another link between the floras of New Zealand and South America; it, according to Kükenthal, having up to the present only been known as occurring in Patagonia.

Carex dissita, Sol., var. **neesiana** (Endl.), Kük.

Chatham Island, but exact station uncertain. Probably the *C. lambertiana* of Buchanan's list (*l.c.*).

Carex litorosa, Bailey.

Sea-shore, Broad Bay, South Westland.

LILIACEÆ.

Astel petriei, Cockayne.

Subalpine meadow, Mount Torlesse Range. This habitat is here given because the plant is essentially one of the wet western region, being particularly common in the alpine meadows of Westland.

AMARYLLIDACEÆ.

Hypoxis pusilla, Hook. f.

Abundant on the stony plain near West Melton, Canterbury Plain.

FAGACEÆ.

Nothofagus menziesii (Hook. f.), Oerst.

Occurring gregariously in the *Nothofagus cliffortioides* forest, and can be recognised at a distance by its colour and form. Junction Hill and Poulter Mountains, near source of River Poulter.

URTICACEÆ.

Urtica ferox, Forst.

(1.) Near roadside, Jackson's, Westland, distant twenty-four miles from the sea. (2.) Forming, with *Muehlenbeckia adpressa* and *Pteris incisa*, a dense thicket at base of rocks near the sea.

POLYGONACEÆ.

Muehlenbeckia ephedrioides, Hook. f.

Stony bed of River Conway, near its source, south Marlborough.

CHENOPODIACEÆ.

Atriplex billardieri, Hook. f.

Shore of Ruapuke Island, Foveaux Strait.

Rhagodia nutans, R. Br.

Rocky places near sea, Banks Peninsula, Canterbury.

RANUNCULACEÆ.

Ranunculus traversii, Hook. f.

Source of the River Poulter, in the Snowcup Mountains, not far from where Travers originally discovered this species. I also collected it on Walker's Pass; it is therefore probably found in alpine meadows all over the Snowcup Range. The plant, which is here referred to the above species, has the leaves both reniform and peltate, while the flowers are pale-yellow, and not cream-coloured as described by Hooker. Mr. T. F. Cheeseman is of opinion that this plant is not *R. traversii*. It has somewhat the appearance of being a hybrid between *R. lyallii* and a large-flowered yellow buttercup growing in the same locality, which is either a variety of *R. munroi* or of *R. insignis*.

Ranunculus sericophyllus, Hook. f.

(1.) On old morainic deposit near source of River Otira, Westland. (2.) Very plentiful near source of River Poulter, in the Snowcup Range, growing on a stony slope in soil of little depth, but moist, and containing plenty of humus.

Ranunculus lyallii, Hook. f.

One plant observed almost at sea-level, Milford Sound, west coast of Otago.

Ranunculus tenuicaulis, Cheeseman.

(1.) Sources of River Poulter. (2.) Kelly's Hill, Westland. In the "Students' Flora," Craigieburn Mountains is given on my authority, but this is a mistake, the specimen having been collected in Westland.

MONIMIACEÆ.

Hedycarya arborea, Forst.

Forest, Preservation Inlet. This habitat is cited because the neighbourhood of Jackson's Head is given in the "Forest Flora" as the then-known southern limit of this plant on the west of the South Island.

CRUCIFERÆ.

Cardamine enysii, Cheeseman.

On rocks, source of Nigger Creek, Candlestick Mountains, northern Canterbury, at altitude of about 1,400 m.

ROSACEÆ.

Acæna glabra, Buchanan.

A frequent plant of subalpine shingle-slips and dry stony ground in all parts of the eastern climatic region of the Waimakariri, Canterbury.

Geum uniflorum, Buchanan.

An extremely common plant of subalpine and alpine meadows and moist, shady, rocky places in Westland.

LEGUMINOSÆ.

Swainsonia novæ-zelandiæ, Hook. f.

Growing on shady side of a shingle-slip facing east, in fine stony *débris* which is rather moist; some of the plants under shade of stunted beech-trees, Mount Torlesse Range, at altitude of 1,010 m. I also saw it at 1,050 m., growing on summit of a rock in very shallow soil in shade, and again at 1,100 m. as a plant of the alpine meadow growing on a steep slope of dry stony loam facing north and north-east.

RUTACEÆ.

Melicope mantellii, Buchanan.

In low forest near River Hapuka, Kaikoura district, Marlborough.

ELÆOCARPACEÆ.

Elæocarpus hookerianus, Raoul.

Forest on Bluff Hill, Southland (Captain and Mrs. J. Bollons).

ARALIACEÆ.

Nothopanax simplex (Forst. f.), Seem., var. **parvum**, Kirk.

(1.) On river-flat, Kelly's Creek, Westland (D. Petrie and L. Cockayne). (2.) Now forming a portion of the new growth where the forest was cleared some years ago for the Midland Railway, near the River Teremakau, Westland.

Pseudopanax lineare, C. Koch.
Frequent in Westland subalpine scrub.

UMBELLIFERÆ.

Angelica trifoliata (Hook. f.), Cockayne.
Sphagnum bog near summit of Porter's Pass, Canterbury.

Aciphylla colensoi, Hook. f., var. **conspicua**, T. Kirk.
Common in the subalpine meadows of the Snowcup Mountains, Canterbury and Westland.

BORAGINACEÆ.

Myosotis capitata, Hook. f., var. **albiflora**, J. B. Armstg.
Growing in peat, on moist rocks, in shade. Shore of Foveaux Strait, base of Bluff Hill, Southland.

Myosotis antarctica, Hook. f., subsp. **traillii**, T. Kirk.
Gravelly beach, Waipapa Point, shore of Foveaux Strait. A plant from this locality is growing well on the rockery, Biological School, Canterbury College.

SCROPHULARINACEÆ.

Veronica cheesmanni, Benth.
On old moraine near source of Otira River, Westland Only a few plants observed.

Veronica haastii, Hook. f.
On stony *débris*, facing east, Mount Rolleston, Arthur's Pass.

Veronica raoulii, Hook. f.
Stony river-bed of River Hawkins, Canterbury Plain (T. W. Adams).

Calceolaria repens, Hook. f.
On shady moist rocky banks, in company with *Nertera depressa*, *Fostera sedifolia*, and *Gunnera monoica*, Otira Valley, Westland. Also in shade of forest, on rocks, Mount Rangitaipo, in lower subalpine region.

PLANTAGINACEÆ.

Plantago uniflora, Hook. f.
On flat sandy ground formerly occupied by dunes near New Brighton, Canterbury.

COMPOSITÆ.

Olearia excorticata, Buchanan.
Subalpine scrub of Westland; not uncommon.

Olearia capillaris, Buchanan.

In *Nothofagus* forest, bank of northern branch of River Poulter, at altitude of about 800 m.

Senecio rotundifolius, Hook. f.

Near shore, south of Bluff Harbour, Southland. This records the occurrence of this plant much further to the east than given in the "Forest Flora," p. 234.

Helichrysum pauciflorum, T. Kirk.

On dry rocks, Candlestick Mountains, at altitude of 1,200 m. Previously recorded from only one locality. It probably occurs on alpine rocks in many parts of the drier mountains of Canterbury.

Helichrysum coralloides, Benth. and Hook.

Source of the River Conway, South Marlborough.

Senecio latifolius, Banks and Sol.

Extremely common near the head-waters of the River Poulter, as it issues from its gorges.

Celmisia walkeri, T. Kirk.

A most characteristic plant of the subalpine meadows of Westland, and of moist rocky places in the same region.

Celmisia petiolata, Hook. f.

Alpine meadow at source of River Kowhai, Mount Torlesse Range (A. H. Cockayne).

Celmisia spectabilis, Hook. f.

Rare in subalpine and alpine meadows of Westland. This is essentially a species of the drier mountain regions.

Haastia sinclairii, Hook. f.

On shingle, summit of Kelly's Hill, Westland.

Gnaphalium paludosum, Petrie.

Wet ground, Arthur's Pass.

Raoulia haastii, Hook. f.

A most abundant plant on recently formed dry subalpine river-beds, forming large green cushions.* Western part of the Waimakariri River basin. Also on river-terrace, Otira Valley, Westland.

* See photo in Schimper's Pflanzengeographie, p. 685, fig. 392.

Art. XXXVII.—*On the Defoliation of* Gaya lyallii, *J. E. Baker.*

By L. Cockayne, Ph.D.

Communicated by A. H. Cockayne.

[*Read before the Wellington Philosophical Society, 2nd November,* 1904.]

In a paper published by me some years ago* in which the seedling form of *Gaya lyallii*, var. *ribifolia*, is described I threw grave doubts on the hitherto universally accepted opinion that *G. lyallii* is an evergreen at below 3,000 ft. and a deciduous tree at and above that altitude. In support of my opinion the behaviour of cultivated plants at almost sea-level of both the typical form and var. *ribifolia* is cited, as also of young plants grown under frostless and almost frostless conditions. In all these cases the plants were perfectly deciduous. At an altitude of about 2,000 ft., on the outskirts of the Thirteen-mile Bush, situated on the slopes of Big Ben, *Gaya lyallii*, var. *ribifolia*, is abundant. Happening to be in the above locality in October, 1903, I paid special attention to the plant under consideration, and found in every instance the trees quite bare of leaves. To place this fact on record I took a photograph of a grove of these trees (Photo No. 348), which has been sent to several of my correspondents.

Gaya lyallii, var. *ribifolia*, is essentially a plant of the dry eastern mountain region, while *G. lyallii* occurs in the much wetter western region. It only remains now for some observer to note the behaviour of the western plant at a low level, when in all probability it will also be found to be leafless in the early spring.

Art. XXXVIII.—*Notes on the Vegetation of the Open Bay Islands.*

By L. Cockayne, Ph.D.

Communicated by A. H. Cockayne.

[*Read before the Wellington Philosophical Society, 2nd November,* 1904.]

Plate XXIII.

1. General Remarks.

Lying in the Tasman Sea, some three nautical miles from the shore of south Westland, almost opposite the mouth of the Okuru River, are the two small islets known as the Open Bay

* Trans. N.Z. Inst., vol. xxxiii., 1901, p. 273.

Islands. From their structure, and from what is known regarding the geological history of New Zealand, they evidently at no very distant date formed a portion of the mainland. It seems, then, instructive from a phytogeographical point of view to give a brief sketch of their vegetation, at the same time comparing it with that of the adjacent coast, so that the effect of isolating such coastal vegetation upon a gradually diminishing land-area and exposing it in consequence to slowly increasing unfavourable conditions may be estimated. The importance of this study is also very much enhanced from the fact that the vegetation of the islands is quite in its primeval condition, there having been no settlement of any kind, and, so far as I could observe, with the exception of a few plants of *Poa annua*, introduced plants are absent.

Now, the coast of Westland, thanks to the excessive rainfall of more than 254 cm. yearly, is covered almost to high-water mark with a dense forest, made up of numerous species of plants, but which differ in numbers and grouping according to the drainage conditions of the ground. Such a forest is, however, a typical evergreen rain-forest, and contains many epiphytes, lianes, tree-ferns, mosses, and liverworts. As for the lianes, the tree-trunks are frequently so thickly covered with climbing species of *Metrosideros* or *Freycinetia banksii* that their bark is quite hidden. With forest similar to the above would the Open Bay Islands be covered when forming part of the mainland.

During a trip in the Government steamer "Hinemoa" I had the rare opportunity of visiting these islands, in February, 1903, and it is from notes hastily taken during that visit that this paper is compiled.

The islands are two in number, divided from each other by a narrow strait. The larger and more northerly of the two is perhaps at most half a mile in length. On the east its surface terminates abruptly in precipitous cliffs, ranging in height from 15 m. to 30 m., but towards the west it gradually slopes to the sea. To the north and west are many flat rocks, which are left quite bare at low water. At the southern extremity this island is cut into two unequal parts by a deep chasm, through which the sea dashes at high water. The smaller island consists of a low conical hill 45 m. or thereabouts in height.

Both islands are formed of limestone, which is overlaid by a rather deep covering of soil, consisting of coarse, dark-coloured peat, containing a considerable percentage of imperfectly decayed vegetable matter. This soil is extremely loose, both from its texture and from being honeycombed with the holes of mutton-birds. It is also saturated with water, so that, when

dug into, moisture from all sides flows into the newly-made cavity. At the bottoms of the mutton-birds' holes, too, water must sometimes lie.*

At the southern extremity of the northern island is the remains of an old beach, or river-terrace, built up of rounded stones firmly cemented together, none of which contain lime. This formation Mr. G. J. Roberts, Chief Surveyor for Westland, informs me is of glacial origin, and corresponds to similar deposits on the mainland.

Both islands are densely covered with vegetation, and the flat rocks mentioned above contain many deep pools in which seaweeds are abundant, while the rocks themselves are thickly covered with *Hormosira banksii*.

2. Vegetation of the Larger Island.

(*a.*) *Plants of Rocks.*

The richness of plant life on the rocks depends chiefly on their position with regard to sun and wind, and upon the steepness of the rock-face. Where the cliffs are in the shade, and consequently always more or less wet, they are densely clothed with vegetation; but in other places the plant-formation is an open one, the plants occurring in larger or smaller patches, while in others again the rocks are bare, except for lichens. Over the top of the precipices† facing the mainland hangs *Veronica elliptica*. Below this belt is frequently a zone of *Asplenium obtusatum*, beneath which are long vertical breadths of *Tillæa moschata* and *Lepidium oleraceum* mixed together. *Samolus repens* occurs on the drier portions of the rocks, occupying crevices, and thus sometimes making long lines more than 2 m. in length and some 17 cm. in breadth. Finally, in some places the thick-leaved fern *Lomaria dura* grows more or less luxuriantly.

On the flat rocks at the northern end of the island are *Samolus repens*, *Apium prostratum*, *Scirpus nodosus*, young plants of *Veronica elliptica*, *Phormium tenax* at the margin of the rocks coming almost to the water's edge, and in some places are masses of *Rumex flexuosus* with shoots attaining a length of $\pm$ 1 m.

(*b.*) *Zonal Distribution of Plants on Surface of Island.*

As seen from the above description of rock-vegetation, the distribution is in part zonal, but the surface of the island, espe-

* This is the station where the leech recently described by Dr. W. B. Benham under the name *Hirudo antipodum* was discovered by Mr. W. Dunlop and myself. (See Trans. N.Z. Inst., vol. xxxvi., p. 185, 1904.)

† Here is the breeding-ground of the spotted shag (*Phalacrocorax punctatus*), large numbers of young being on the cliffs and adjacent rocks at the time of our visit.

cially that of the smaller southern portion, shows such distribution in a more striking manner. Commencing near the edge of the cliffs, or in some places extending on to the cliffs themselves, is a zone of *Tillæa moschata*, sometimes quite pure, or in other places intermingled with *Samolus repens* and *Apium prostratum*. The *Tillæa* is in certain situations, especially where the ground is particularly wet, of great luxuriance—the stems, *e.g.*, about 32 cm. in length, with the lower half prostrate and bare, but conspicuous through its red colour, while the upper half is erect and covered thickly with short succulent green leaves. In some places *Tillæa* may be wanting, in which case the continuity of the zone is preserved by breadths of *Lepidium oleraceum*, with spreading shoots ± 72 cm. in length. The "*Tillæa* zone" is succeeded by a second one consisting of *Carex comans*, 4 m. or more in width, the individual plants forming pale-coloured tussocks 17 cm. tall, and with a spread of 32 cm.

The third zone, about 9 m. in breadth, consists of the very common maritime fern *Asplenium obtusatum*, growing densely and with the thick coriaceous fronds 44 cm. tall. These arise from stout creeping rhizomes, ± 30 cm. in length by ± 22 cm. in circumference—*i.e.*, if the bases of the fallen fronds be included—the actual rhizome measuring only ± 3·5 cm. × ± 3 cm. Such large breadths of dense fern, with the fronds of a uniform height, and all touching, make a remarkable sight (see Plate XXIII.). As showing the looseness of the soil in which this fern grows, pieces of rhizome were pulled up with peat attached measuring 73 cm. × 50 cm.

Succeeding the zone of pure *Asplenium obtusatum* is in some places a fourth zone, of which a well-marked variety of *Veronica elliptica* is occasionally the principal plant, or this may be mixed with or replaced by *Muehlenbeckia adpressa*, combined with certain other plants. The *Veronica elliptica* is 4 m. or more in height, the main trunk is prostrate at the base, then ascending and spreading with straggling branches. This variety of *Veronica elliptica* is quite distinct from any with which I am acquainted, it having remarkably large leaves. As it does not appear to vary to any extent, and since the climatic conditions of the Open Bay Islands are not such as might be expected to favour a luxuriant development of leaf, but rather the contrary, most probably this is a constant variety and would "come true" from seed. It would be consequently a matter of considerable interest to procure seeds and raise plants, so as to settle this question. Also, plants could readily be propagated from cuttings, and then grown under different conditions, so as to observe if the leaf-form could be easily modified. *Asplenium obtusatum* grows densely in many places beneath the bushes of *Veronica* associated

with *Astelia nervosa.** Frequently, too, *Pteris incisa* is mixed with the *Asplenium*, above the dark-green fronds of which its much paler green leaves rise to a height of 20 cm. or more. Very frequently the *Veronica* is accompanied with, or indeed it may be entirely replaced by, *Muehlenbeckia adpressa* associated with *Pteris incisa* and *Asplenium obtusatum*, which the liane binds together into a dense thicket of greenery, above which its ultimate shoots are raised for some 28 cm., at first straight, but finally winding towards their apices. Such a thicket, especially if *Veronica* be present, is about as tall as a man of medium height.

(*c.*) *Liane Formation of* Freycinetia banksii.

By far the greater part of the larger island is occupied by a most interesting formation of which the liane *Freycinetia banksii* is the dominant plant, and it is the existence of this and the above-described *Muehlenbeckia* formation that makes the Open Bay Islands of special phytogeographical interest.

This *Freycinetia* formation forms a "scrub," ± 1·9 m. tall, of the most extreme density, the stout shoots, ± 12 cm. in circumference, twisted in all directions. Sometimes there is little else than *Freycinetia*, but frequently the scrub becomes still denser through an admixture of *Muehlenbeckia adpressa* and *Calystegia tuguriorum*.

Between the *Freycinetia* formation and the cliffs or shore is frequently "*Veronica* scrub," or in places *Pteris incisa*, with *Phormium tenax* growing through it. On the island are also a few plants of *Cordyline australis*, and one plant of *Schefflera digitata* was noted. I think also that Mr. Roberts told me he had noticed a plant of *Metrosideros lucida* when making a survey of the island many years ago.

3. Vegetation of the Smaller Island.

The most interesting fact regarding the vegetation of the smaller island is that although the principal plant-society is a liane formation, yet it is *Muehlenbeckia* and not *Freycinetia* that is dominant, the latter being, so far as I saw, altogether absent, just as it is on the smaller half of the larger island.

The island under consideration, as pointed out above, consists of a conical hill, and at low water flat rocks extend uncovered for some distance seawards. On these rocks, but just above high-water mark, is *Lepidium oleraceum* associated with large masses of *Tillœa moschata*. *Asplenium obtusatum* is also on these flat rocks, and in some places near the sea is *Carex comans*.

* Syn. *Astelia grandis*, Hook. f.

In one place where the ground is boggy are large quantities of *Carex ternaria** together with *Hydrocotyle americana*,† but where the ground is drier at this point is *Muehlenbeckia complexa* growing over *Lepidium oleraceum* and *Asplenium obtusatum*.

Excepting in the immediate neighbourhood of the shore the remainder of the island is occupied by a dense growth of "*Muehlenbeckia* scrub," at first mixed with *Veronica elliptica*, but afterwards, towards and at the actual summit of the island, it is almost pure *Muehlenbeckia*.

4. ORIGIN OF THE LIANE FORMATIONS.‡

That the Open Bay Islands have formed a part of the South Island mainland at no very distant date, as stated above, there can be no doubt: the shallowness of the sea, the glacial deposit on the main island, and other facts connected with the general geological history of New Zealand, which need not be cited here, offer ample proof.

The islands when forming part of the mainland would be densely covered with an evergreen subtropical forest, as mentioned before, similar to that which occupies the whole coast of south Westland at the present time, and which is very briefly described at the beginning of this paper. In such a forest, it may again be pointed out, *Freycinetia banksii* is a most conspicuous feature, climbing the highest trees and in some places spreading over the forest-floor. *Muehlenbeckia adpressa*, too, as in nearly all New Zealand lowland forests, is by no means uncommon. With the separation of the Open Bay Islands from the mainland the forest would be at first exposed to few deleterious influences, but as the area that it occupied became gradually smaller and smaller, so would the forest be exposed more and more to the furious north-west wind laden with sea-spray, until, by slow degrees, those plants unable to endure such conditions, such as most rain-forest hygrophytes, would go to the wall, while those plants possessing a more xerophytic structure would be better able to survive. Notwithstanding that lianes are amongst the most highly specialised of forest plants, their whole organization having been evolved by forest conditions, they are usually more xerophytic than the trees

* This also occurs in some low ground on the larger island in the midst of "*Muehlenbeckia-Veronica-Pteris* scrub."

† I am indebted to my friend Mr. D. Petrie, M.A., for the identification of this species.

‡ A preliminary account of this was given in a paper read by me at the Dunedin meeting of the Australasian Association for the Advancement of Science, and published in the Canterbury Agricultural and Pastoral Association Journal, vol. vi., 1904, p. 7.

with which they are associated,* since by virtue of their comparatively slender but extremely long stems they have to possess special adaptations in order to procure a sufficient supply of water for their leafy shoots high on the tree-tops. Thus, as the forest trees gradually died, the lianes in question would become dominant, and, uniting themselves with certain coastal plants, and evading the wind by no longer climbing up aloft, be able to maintain themselves in comparative luxuriance. Leaving out of the question any xerophytic structure, this power of certain lianes to assume a shrubby habit, through the interlacing or twining of their shoots, gives them a great advantage over forest trees when exposed to furious gales.

Further evidence of the ancient forest formation is afforded by the plants of *Schefflera digitata* and *Metrosideros lucida*. *Phormium tenax*, *Cordyline australis*, and *Arundo conspicua* would, on the contrary, be rather plants of the forest's outskirts, *Phormium tenax* especially occurring frequently as a belt near high-water mark.

Judging from the ordinary coastal plant-formations of south Westland, there should appear nothing surprising in the *Freycinetia* formation of the Open Bay Islands, insomuch as *Freycinetia* in many places forms an outlier of the present forest formation, in company with certain shrubs and low trees, growing very close indeed to the sea. *Muehlenbeckia adpressa*, too, frequently remains as a somewhat ball-shaped bush of the open where the forest has been cleared, and in some places it too comes to high-water mark, as *e.g.* near Nugget Point, in Otago, where, with the shrubby nettle, *Urtica ferox*, and certain ferns, it forms dense thickets, probably in places where the forest has been removed. *Muehlenbeckia complexa*, too, on the Port Hills, Canterbury, and elsewhere, no longer a forest plant, forms dark-coloured round or pyramidal shrubs, which are so frequent on the tussock slopes as to give a peculiar physiognomy to the landscape. Many other examples of lianes taking a shrub form in the open after the removal of forest could be adduced, but the above must suffice here.

An interesting fact in the distribution of plants on the Open Bay Islands, and one for which I can offer no adequate explanation, is the non-occurrence of *Freycinetia* on the smaller island. On the larger island, also, it does not occur on the smaller part. It may be that in the struggle for existence the *Muehlenbeckia* may have some slight advantage over the *Freycinetia* which

* Thus Warming writes: "Blattbau und Sprossbau eines Teiles der Lianen erinnern an den Bau der Xerophyten." Lehrbuch der ökologischen pflanzengeographie, Zweite Auflage der Deutschen Ausgabe, 1902, p. 110.

we are unable to estimate, and that where the two plants are associated the latter is being slowly eradicated. Such silent conflicts, of which we know nothing, must be constantly waged between plants which apparently are equally well equipped for the struggle.

5. SUMMARY.

(1.) The Open Bay Islands are two small islets three nautical miles from the coast of south Westland, to which they must have been joined at no very distant date.

(2.) Their most important vegetation consists of thickets formed by the lianes *Muehlenbeckia adpressa* and *Freycinetia banksii*.

(3.) On the larger island *Freycinetia* is dominant, associated with *Muehl. adpressa*, *Calystegia tuguriorum*, and *Pteris incisa*, or it may be almost pure.

(4.) On the smaller island there is no *Freycinetia*, but the thicket consists of *Muehlenbeckia adpressa* associated with *Veronica elliptica* and *Pteris incisa*, or the *Muehlenbeckia* may be pure.

(5.) The form of *Veronica elliptica* is distinct from any found elsewhere in the New Zealand biological region. Probably this form may reproduce itself "true" from seed.

(6.) Owing to the heavy rainfall there is in places a luxurian rock-vegetation.

(7.) In certain places not occupied by "liane scrub" there is a well-marked zonal distribution of certain New Zealand coastal plants.

(8.) When attached to the mainland the present islands must have been occupied by subtropical evergreen rain-forest similar to that now existing on the adjacent coast. After separation, as the area of the islands became smaller and smaller, and the climatic conditions more and more severe, only those plants specially adapted to such conditions could survive, and of these certain of the lianes, although most highly specialised forest plants, are the most suitable.

(9.) On the smaller island the dominant liane is *Muehlenbeckia adpressa*; and *Freycinetia banksii*, the dominant liane of the larger island, is altogether wanting.

6. LIST OF PLANTS (SPERMAPHYTA AND PTERIDOPHYTA) OBSERVED ON THE OPEN BAY ISLANDS.

Filices.

Asplenium obtusatum. *Forst.*
Lomaria dura, *Moore.*
Pteris incisa, *Thunb.*

Pandanaceæ.

Freycinetia banksii, *A. Cunn.*

Gramineæ.

Poa annua, *L.* (*adv.*).
Agrostis (?) *sp.*
Arundo conspicua, *Forst. f.*

Cyperaceæ.

Scirpus nodosus (*Br.*), *Rottb.*
Carex comans, *Bergg.*
Carex ternaria, *Forst. f.*

Liliaceæ.

Cordyline australis (*Forst.*), *Hook. f.*
Astelia nervosa, *Banks and Sol*

Polygonaceæ.

Muehlenbeckia adpressa, *Lab.*
Muehlenbeckia complexa (*A. Cunn.*), *Meissn.*
Rumex flexuosus, *Soland.*

Cruciferæ.

Cardamine hirsuta, *L.*
Lepidium oleraceum, *Forst. f.*

Crassulaceæ.

Tillæa moschata (*Forst.*), *DC.*

Myrtaceæ.

Metrosideros lucida (*Forst. f.*), *A. Rich.*

Araliaceæ.

Schefflera digitata, *Forst.*

Umbelliferæ.

Apium prostratum, *Labill.*
Apium filiforme, *Hook.*

Primulaceæ.

Samolus repens (*Forst.*), *Pers.*

Convolvulaceæ.

Calystegia tuguriorum (*Forst.*), *R. Br.*

Scrophularinaceæ.

Veronica elliptica, *Forst. f.*, var.

Compositæ.

Sonchus asper, *Hill.*

EXPLANATION OF PLATE XXIII.

Vegetation near edge of cliffs of larger island, showing zonal arrangement of plants, Open Bay Islands. In centre, the fern *Asplenium obtusatum;* in foreground and to left, the sedge *Carex comans;* nearer to edge here and there may be seen the zone of *Tillæa moschata;* in background, shrubs of *Veronica elliptica*, var., as noted in paper.

ART. XXXIX.—*Notes on Ferns.*

By H. C. FIELD.

[*Read before the Wellington Philosophical Society, 1st June*, 1904.]

IN previous papers I have mentioned peculiar forms of our New Zealand ferns, of which examples had been sent to me by persons who had experienced difficulty in identifying them; and I now note the following:—

Towards the end of last year a Miss Allen sent me a pressed frond of a fern which she had gathered in the bush between Rotorua and Tauranga. It was unmistakably a barren frond of *Lomaria vulcanica*, and only differed from the normal type in being of a bright yellowish-green instead of the usual dark-olive. Her brother, however, has since sent me other specimens, which explain why there had been difficulty in classifying the plant. *Lomaria vulcanica* is usually a tufted fern, producing a crown of fronds, and this is sometimes raised 2 in. or 3 in. above the ground on a short caudex. Old plants often produce external crowns, and spread in this way over a space of 1 ft., or nearly so, in diameter. The form, however, which Miss Allen found has widely spreading creeping rhizomes, about $\frac{1}{8}$ in. in diameter, dark-brown in colour, and slightly scaly, from which the fronds grow at intervals of several inches. It is evident that this fern, like several others of our New Zealand ones, occurs in two forms, and I think it would be well to distinguish this creeping variety as "*repens.*"

Miss Allen afterwards sent me, from the Piako Swamp, some fronds of what she supposed to be the *Nephrodium thelypteris*, but which proved to be *Nephrodium unitum*. This latter fern

is also a tufted plant, usually growing in volcanic soil in the immediate vicinity of hot springs, and used to be particularly abundant along the banks of the hot stream which flowed from Rotomahana into Lake Tarawera, from whence I brought a couple of plants a few weeks before the eruption, and had them growing in my greenhouse for about nine years.

Mr. Allen has since sent me a couple of plants from the Piako Swamp, which present very peculiar features. Instead of the fronds being produced from a crown in the ordinary manner, they grow from a sort of underground caudex about 18 in. long. It is evident that when the plants first grew the surface of the swamp was fully 18 in. below its present level, and that as it has risen, by reason of the growth and decay of the *Sphagnum* moss, the fern has been compelled to raise its crown higher and higher, so as to avoid being smothered, and reach the daylight. In this way the underground caudex has been formed; but it is evident that this caudex is an elongation of the actual crown, since, instead of the fronds being produced on the top in the ordinary way, they grow out of the sides of the caudex, a foot or more below the surface, and have struggled up through the moss with such difficulty that the actual fronds are very small, and situated at the ends of an extremely long stalk. The plants are evidently very old ones, and as they rose by reason of the greater elevation of the surface of the swamp, the caudices have become forked, in one case into two and in the other into three branches. I have potted the plants in leaf-mould, in order to see whether, under cultivation, they will revert to the ordinary type.

Mr. Allen also sent me a curious specimen from the bank of the Piako Swamp. It has a long stipes, and the frond is branched and slightly crested. The pinnæ form parallelograms with two obtuse and two acute angles, and are connected with the rachis, at one of the latter angles, by a short stalk. The edges of the pinnæ are indented into short rounded or obtusely pointed lobes. Altogether the specimen at first sight looks like a curious harsh form of *Adiantum*. On closer inspection, however, its brown channelled stipes, furnished with scattered scales, shows it not to be an *Adiantum*, but an abnormal form of *Aspidium richardii*, one of our commonest New Zealand ferns.

It is well that fern-collectors should know of these peculiar forms of our ferns, so as to be able to classify their specimens more easily, and therefore I send you these notes.

ART. XL.—*On the Occurrence of Starch and Glucose in Timber.*

By H. B. KIRK, M.A., Professor of Biology in Victoria College, Wellington.

[*Read before the Wellington Philosophical Society, 13th April,* 1904.]

IN the course of work on the histological character of New Zealand timbers, I was struck with the frequency with which starch is found in kahikatea or white-pine (*Podocarpus dacrydioides*). It seemed that this might have some connection with the peculiar liability of white-pine to be attacked by the boring larva of a beetle, and I was led to examine as many specimens as possible of worm-eaten timber of this kind. The result was that in nearly every case in which the timber was so attacked starch was found to be present either in the medullary rays or in the xylem parenchyma, and the few samples of worm-eaten white-pine that did not contain starch contained abundant glucose.

In a paper read before the Australasian Association for the Advancement of Science, in January of this year, I suggested that kahikatea might always be relied on to yield the satisfactory results that it has sometimes been found to yield, if it were cut when the stored starch has been converted into soluble glucose for the use of the plant, and if the converted timber were allowed to remain for some time exposed to the action of water to dissolve out the glucose. With the kind assistance of Mr. Holmes, of the Public Works Department, and of others, I am endeavouring to determine at what time starch ordinarily disappears from the tissues.

Since January I have examined many other samples of worm-eaten timber, and find that timber attacked by larvæ of beetles contains either starch or glucose, usually the former. Of course my observations are not at present by any means exhaustive, and there is in all cases great difficulty in ascertaining with any certainty even the approximate time at which the timber was felled. Excluding kahikatea, the samples noted here have been examined.

Rimu (*Dacrydium cupressinum*): Worm-eaten samples usually contain starch both in rays and in xylem parenchyma. When starch is absent much glucose is present. Five samples.

Matai (*Podocarpus spicata*): As in the case of rimu. Four samples.

Totara (*Podocarpus totara*): Two samples. No starch, abundant glucose.

Kauri (*Agathis australis*): Seldom attacked. The two samples are both from buildings in which there is much worm-eaten kahikatea. One contains starch in the medullary rays; the other contains much glucose.

An Australian timber, said to be swamp-gum, was used in the construction of a barge for the sugar-refinery at Auckland. Captain Broun sent to the Agriculture Department a portion of the timber from this barge riddled by the larvæ of a beetle. Starch is abundant in both rays and parenchyma.

American axe-handles, ash, in the museum of the Agriculture Department, part of a shipment attacked by larvæ of beetles, contain starch in rays and xylem parenchyma.

Chip pill-boxes in the same museum, part of a worm-eaten shipment, show much starch in the tissues. They are of coniferous wood.

Maire frequently contains starch. I have not seen worm-eaten specimens, but am informed that this timber is frequently attacked. The same remarks apply to tawa.

These instances, though insufficient to prove that it is usually for starch, and when not for starch for glucose, that the larvæ of beetles attack timber, are, it seems to me, sufficient to justify greater care in the selection of timber. No timber should be accepted for use in a sheltered position if starch is found in it, or if, in the absence of starch, it contains much glucose; and examination for the detection of these substances should not be confined to the surface of the timber or to the outer parts of the tree.

Art. XLI.—*Revised List of New Zealand Seaweeds.*

By R. M. Laing, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 2nd November*, 1904.]

Appendix I.

I intend from time to time, as opportunity offers, adding to my list of New Zealand seaweeds, in order to keep it as far as possible up to date. I shall not amend the original list except where it is obviously wrong. The appendices, therefore, will include only such species as have been found since the original list was published, or such old species as have been found by the early voyagers and rejected by Agardh, but rediscovered and identified by later investigators. Most of the species in this paper have been identified by Major Reinbold, of Itzehoe, and I have again to thank him for his unfailing kindness to me.

Subclass CHLOROPHYCEÆ.

390. *Ostreobium reineckei*, Born. ("Flora of the Samoan Islands," by Reinecke, in Engler's Bot. Jahrbuch, 1896.)

This is the first shell-perforating alga to be recorded from New Zealand. No doubt others will be found when looked for.

The disappearance of shells from beaches is often to a considerable extent due to the action of these algæ. The shells from which this species was obtained were picked up out of the mud at Diamond Harbour, Lyttelton. Reinbold states that they also contained a plant closely resembling *Gomontia polyrhiza*, but, as the material was sterile, this determination is not certain.

Order Cladophoraceæ.

391. *Cladophora simpliciuscula*, Kg., Phyc. Gener., p. 262 (= *C. subsimplex*, Kg., Tab. Phyc.).
St. Clair: *R. M. L.*

392. *Rhizoclonium africanum*, Kg. (? *R. ambiguum*, Hook.).
Mouth of Kaikorai Stream, Otago: *R. M. L.*

Order Ulvaceæ.

393. *Enteromorpha flexuosa*, J. Ag. (Small form.)
Mouth of Waimakariri: *R. M. L.*

394. *Enteromorpha torta*, Rbd. (= *E. percussa*, Harv., partim).
Mouth of Kaikorai Stream, Otago: *R. M. L.*

Subclass PHÆOPHYCEÆ.

Order Dictyotaceæ.

395. *Dictyota dichotoma*, Lmrx., var. *implexa*.
Stewart Island: *R. M. L.*

Subclass FLORIDEÆ.

Order Ceramiaceæ.

396. *Antithamnion ternifolium*, Hook. and Harv., Lond. Journ., iv., p. 272.
North Mole, Timaru: *R. M. L.*
Of my specimens Major Reinbold says, "More robust and more richly ramified than the type" (Flor. Antarct., pl. 189, fig. 2). If the plant does not belong to this species, it is at least very near to it.

397. *Ptilothamnion schmitzii*, Heydrich, Berichte der deutschen botanischen Gesellschaft, vol. xi., 1893.
Bay of Islands: *Heydrich.*

398. *Sporoclonium pastorale*, R. M. L., Trans. N.Z. Inst., 1904.
Wycliffe Bay, Otago Peninsula: *R. M. L.*

399. *Ceramium discorticatum*, Heydrich, *loc. cit.*
Bay of Islands: Heydrich.

400. *Ceramium laingii*, Rbd. MS. (sp. nov.).
On *Codium mucronatum*, Riverton: *R. M. L.*
The following is Reinbold's description of the species: "Minutum (5–10 mm. altum) sed admodum crassum, continue

corticatum (articulis perbrevibus vix dignoscendis) superne dense lateraliter ramosum, fronde inferne indivisa, ramulis prolificantibus vestita, ramis valde decompositis, ramulis corymbosa—subfastigiatis apicibus strictis vel (plerumque) divaricatis, acutis, sphaerosporis in ramulis unilateraliter margine quasi immersis et leviter protuberantibus, series longitudinales formantibus."

In habit the species is near to *C. pusillum*, from which it is sharply differentiated by the position of the tetraspores. The tetraspores of *C. pusillum* are verticillate and immersed round the nodes.

Order Cryptonemiaceæ.

401. *Thamnoclonium claviferum*, J. Ag., Epic. Florid., p. 168. (= *T. hirsutum*, Harv., Phyc. Austr., tab. 293).
Foveaux Strait: *R. M. L.*

Order Gigartinaceæ.

402. *Dicranema grevillei*, Lond. Bot. Zeit., 1845, p. 56. (J. Ag., Epic. Florid., p. 435.)
Foveaux Strait: *R. M. L.*

403. *Callocolax neglectus*, Schmitz. (Batters, in "Annals of Botany," vol. ix., June, 1895.)
On *Callophyllis hombroniana*, Timaru: *R. M. L.*
This plant is probably sufficiently close to the English and Continental species to be identified with it.

Order Areschougiaceæ.

404. *Thysanocladia laxa*, J. Ag., Epic., p. 288.
Foveaux Strait: *R. M. L.*

405. *Areschougia laurencia*, Hook. and Harv., Lond. Journ., vi., p. 409. (J. Ag., Epic. Florid., p. 282.)
Foveaux Strait: *R. M. L.*

Order Rhodymeniaceæ.

406. *Plocamium hookeri*, Harv., Alg. Ant., p. 9. (J. Ag., Epic., p. 337.)
Macquarie Islands: *A. Hamilton!*

407. *Plocamium procerum*, J. Ag., Epic. Florid., p. 247.
Foveaux Strait: *R. M. L.*
This plant is possibly included in *P. corallorhiza*, Fl. Nov. Zel.

408. *Phacelocarpus alatus*, J. Ag., Epic., p. 399.
Foveaux Strait (?): *R. M. L.*

409. *Curdiæa engelharti*, J. Ag., Spec. Alg., vol. iii., part 4, p. 105.
In large quantities at Akatore, on the coast of Otago, but seen nowhere else: *R. M. L.*

410. *Gracilaria lichenoides*, J. Ag., Spec. Alg., vol. iii., part 4, p. 52.
New Zealand: *Agardh.*

411. *Gracilaria harveyana* (?), J. Ag., Spec. Alg., vol. iii., part 4, p. 65.
New Zealand: *Agardh.*

Order Delesserieæ.

412. *Nitophyllum parvifolium* (?), J. Ag.
St. Clair: *R. M. L.*

Order Gelidiaceæ.

413. *Gelidium intricatum* (Kg.), Grunow.
New Zealand (the exact locality has been lost): *R. M. L.*

Order Rhodomeleaceæ.

414. *Bostrychia similis*, Rbd., spec. nova.
Half-moon Bay, Stewart Island: *R. M. L.*
The following is Reinbold's description: "Bostrychia minuta (usque 15 mm. alta) capillaris, tota corticata, a surculis repentibus et radicantibus intricatis erectiuscula, parce lateraliter (vel subdichotome) ramosa; ramis elongatis (junioribus leviter incurvis adultioribus strictis) hic illic apice furcatis, subacutis, raro ramulis obsessis, stichidiis ovali-lanceolatis longe pedicellatis acumine sterili superatis; siphonibus 7 (inferiore parte) substantia admodum rigida. Chartae vix adhaeret."
"As to the habit our plant resembles in some degree *B. simpliciuscula*, *B. intricata*, and *B. vaga*; but the fronds of the two former species are articulated, not corticated; besides, in *B. simpliciuscula* the rooting apparatus is turned in a peculiar manner. *B. vaga* is amidst all *Bostrychias* sharply characterized by the simple much curved (adult) branches, which are evidently (even for the naked eye) incrassated above the middle. Besides, the cortication of *B. vaga* is less dense than that of our plant."—(*Reinbold, in letter to Author.*)

415. *Rhodomela hookeriana*, J. Ag., Spec. Alg., vol. iii., part 2, p. 881.
The Bluff: *R. M. L.*

Order Helminthocladiaceæ.

416. *Chantransia polyrhiza* (= *Callithamnion polyrhiza*, Harv.).
Riverton: *R. M. L.*

417. *Chantransia interposita*, Heydrich, Deutschen botanischen Gesellschaft, 1893 (? = *C. naumauni*, Asken).
On *Codium*, Bay of Islands: *Heydrich.*

Order Corallineæ.

418. *Melobesia carpophylli*, Heydrich, Deutschen botanischen Gesellschaft, 1893.
Bay of Islands: *Heydrich.*

419. *Lithophyllum* (*Melobesia*) *antarctica*, Hook. and Harv., Fl. Ant., p. 482.
Riverton: *R. M. L.*

Art. XLII.—*On the New Zealand Species of* Ceramiaceæ.

By Robert M. Laing, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 2nd November*, 1904.]
Plates XXIV.-XXXI.

Part I.

Since the publication of the "Handbook of the New Zealand Flora" in 1864, the work done upon the New Zealand species of seaweeds has been scattered through scientific books and journals appearing in Sweden, Germany, France, and England. It is my object in this paper to give short diagnostic descriptions of all the species of the family *Ceramiaceæ* found in New Zealand, thus enabling the New Zealand student to determine without unnecessary difficulty the name of any species he may find. A bibliography of the subject will be found as an appendix to Part II. of this paper. I have clearly indicated what organs of reproduction are known, so that any future worker will be able at once to recognise whether any that he may find have been hitherto described or not. The family *Ceramiaceæ* in New Zealand is moderately well known, but still presents many difficulties to the investigator, the lack of type specimens in our museums often proving an insuperable bar to absolute certainty of identification. I have chiefly followed Engler and Prantl's "Pflanzenfamilien" in the description of the genera, and the accounts of some of the species are based upon the "Epicrisis Floridearum" of J. G. Agardh; but in most cases I have had specimens of my own,* from an examination of which I have been able to give descriptions that are often to a large extent new. I have presented to the Canterbury Museum examples of such species as were procurable and not already represented in it. It is too much to hope, in the absence of type specimens, that my identifications of Harvey's species have in all cases been successful, but I trust that my descriptions are at

* I have to thank Mr. J. Crosby Smith, of Invercargill, for generously placing at my disposition his large collection of *Ceramiaceæ* from southern Otago.

least sufficiently full and accurate to enable any subsequent investigator to determine what plant I have had under investigation.

The cell-dimensions given were obtained from specimens mounted in glycerine jelly, and variously prepared. They may therefore differ from those that would have been obtained from the measurement of fresh specimens. They should, however, at least be relatively correct.

Order FLORIDEÆ.

Fam. CERAMIACEÆ.

The thallus consists of single branched cell filaments, sometimes with an adventitious cortex formed of rhizoids. This false cortex is produced in the genera allied to *Callithamnion* by the outgrowth of the rhizoids from the basal cell of lateral branches. In *Ceramium* and its immediate allies such filaments spring from the upper ends of the cells of the thallus, thus forming a peripheral crown of cells covering the place where the parent cell is joined to the one above it. In some cases the filaments clothe the main cell row, in others they fail to meet, and leave the intervening parts bare. The sporangia are solitary or distributed in groups over the thallus, or confined to special branches, either placed externally on the thallus or hidden in the cortex. The tetraspores are generally in tetrads, but sometimes variously divided. The antheridia are distributed in very varied form over the thallus, and contain generally many tightly packed spermatangia. The carpogonia bearing branches and those bearing the auxiliary cells are generally united in special procarps of various arrangement. The cystocarps are, as a rule, scattered over the upper part of the thallus, or more or less deeply sunk or completely buried in the cortex. The gonimoblasts (of which there are usually two in each cystocarp) form successively several lobes, of which nearly all the cells give rise to spores. The cystocarp if external is entirely naked, or covered only by an involucre of short incurved branchlets.

KEY TO THE NEW ZEALAND GENERA.

A. The branches of the thallus consisting of single rows of cells.

(*a.*) SPERMOTHAMNIEÆ.—Thallus naked or provided with very delicate verticillate ramuli.* Cystocarps terminal on special fertile branches. The fruit-mass of 1 or 2 gonimolobes.

(i.) Thallus with creeping rhizoids and upright laterally branched fertile shoots. Fruit-mass with 2 gonimoblasts .. .. .. 1. *Spermothamnion.*

(ii.) Thallus with creeping rhizoids and upright oppositely or alternately pinnate fertile shoots. Fruit-mass with 1 gonimoblast .. .. .. 2. *Ptilothamnion.*

* The term "ramuli" has been used throughout this paper to denote short limited branchlets, frequently in whorls at the nodes (Ger. *Kurztrieben*).

(*b.*) GRIFFITHSIEÆ.—Thallus naked or provided with very delicate verticillate ramuli. Cystocarps terminal on special fertile branches. The fruit-mass of 1 or 2 gonimolobes.

(i.) The sporangium bearing whorl of ramuli intercalary or apparently terminal. Some of the ramuli sterile, some fertile .. .. .. 3. *Griffithsia.*

(ii.) The sporangium bearing whorl of ramuli near the end of the shoot. The inner ramuli short, branched, and bearing sporangia, and enclosed by one-celled sterile ramuli .. .. 4. *Pandorea.*

(*c.*) MONOSPOREÆ.—Branches of a single row of naked cylindrical cells. Cystocarps terminal on the fertile shoots, with 1 gonimoblast.

(i.) Sporangia divided into more than 4 spores 5. *Pleonosporium.*

(*d.*) CALLITHAMNIEÆ.—Main axis of a single row of naked cells, the lower part clad with rhizoids. Cystocarps lateral, without involucre.

(i.) Sporangia divided into tetrads. Fruit-mass of several rounded gonimolobes .. .. 6. *Callithamnion.*

(*e.*) SPONGOCLONIEÆ.—Main shoot naked, covered with a spongy network of long-celled laterally-branched filaments. Cystocarps terminal on very short lateral branches, thus appearing sessile. Cystocarps of several rounded successively formed gonimolobes, sometimes enclosed in a small-celled patelliform involucre.

(i.) Thallus round, covered with a spongy network. The central axis branched alternately at the joint-cells, not coated with rhizoids. Cystocarps external on the network of the thallus, closed on the underside by the filaments, without patelliform involucre 7. *Spongoclonium.*

B. PTILOTEÆ.—Cell rows of the branches naked or with ramuli. Thallus either coated with rhizoids or with a normal closed cortex. Cystocarps generally enclosed by several involucral branchlets.

(i.) Branches coated with rhizoids or with a normal cortex. Apical cell diagonally segmented. Cystocarps terminal on short fertile pinnæ .. .. .. 8. *Euptilota.*

C. CROUANIEÆ.—Main axis either of a single row of cells with very richly branched ramuli, or with a central axis and cortex, consisting of richly branched filaments tightly packed together.

(i.) Thallus filamentous, main shoot consisting of a single row of cells. Cystocarps in the axil of a solitary ramulus 9. *Ballia.*

(ii.) Thallus filamentous, main shoot consisting of a single row of cells. Cystocarps terminal .. .. 10. *Antithamnion.*

D. SPYRIDIEÆ.—The thallus possesses a central axis which is completely or partially clothed with a cortex consisting of larger cells within and smaller cells without.

(i.) Thallus rounded, branched on all sides, with large-celled central axis. The cortex ring internally large-celled, externally small-celled, and broken only on the weaker shoots .. .. 11. *Spyridia.*

(ii.) Thallus rounded or flattened, dichotomously branched, the dichotomous branches bent inwards like a pair of pincers. Central axis large-celled. Cortex ring continuous, or found only at the nodes .. .. .. 12. *Ceramium.*

(iii.) Thallus completely corticated, with conspicuously large cells internally and small externally .. .. 13. *Microcladia.*

E. Thallus filamentous with creeping rhizoids and erect fertile branchlets. Branches consisting of single rows of cells .. 14. *Rhodocorton.*

Genus 1. SPERMOTHAMNION (Areschoug).

Thallus filamentous with creeping rhizoids attached by haptera, and erect more or less distichously oppositely or alternately branched fertile shoots. Sporangia placed on the lateral branches of the erect shoot, singly or in groups, divided into tetrads. Antheridia rounded, placed on the upper sides of the lateral branches. Cystocarps terminal in groups, tightly enclosed by the involucral branchlets, without pericarp. The fruit-mass consists of 2 paired united gonimoblasts, which are stout and small, with slightly convex loosely woven upper surface, from which the external cells spread out radially and subsequently produce large oval spores.

I have introduced the generic description because I have seen specimens apparently belonging to this genus, from the Sumner Estuary, Dunedin, and Dusky Sound, but the material has been insufficient for the proper definition of the species.

Genus 2. PTILOTHAMNION (Thuret).

Thallus filamentous, rhizoids provided with holdfasts and upright paripinnate (more seldom alternately branched) thallus. Sporangia generally terminal on the pinnules, divided into tetrads. The antheridia and procarps in exactly similar situations. Antheridia oval or elongated. Cystocarps terminal, enclosed in an involucre of a few involucral branchlets, appearing as very small oval tightly closed heads with a single very small stoutish gonimoblast; from this rounded surface the scanty external cells are only partially disengaged, and then subsequently ripen into spores (in basipetal sequence).

1. **Ptilothamnion schmitzii** (Heydrich, "Berichte der Deutschen Botanischen Gesellschaft," vol. xi., 1893).

Thallus carmine-red, ½–1 mm. high, carpeting *Zonaria sinclairii* (Hook. and Harv.), composed of monosiphonous filaments, which remain naked. The first filaments are creeping, 20–30 μ broad, fastened by means of short holdfasts to the substratum; secondary branches upright, simple, seldom branched, 16–20 μ broad. Cells half as long again to twice as long as broad. Procarps either sessile on one-celled secondary filaments, or upon a one- or two-celled stalk on the first or second cell of the filament, overarched by 1 short bent covering ramulus, and consisting of 4 carpogonia. The cystocarps, which are attached similarly to the procarps, are small, rounded, and contain in a colourless pericarp 28 to 30 carpospores. They are overarched by a single large covering-branch. Antheridia are composed of oval bodies at the point of a secondary filament, and have an articulated filamentous axis. Sporangia solitary or in pairs on one- or two-

celled lateral branches. Tetraspores in tetrads. All the reproductive organs come off close together from the same patch of thallus.

Hab. In the Bay of Islands (in June).

I have seen no specimens of this. (R. M. L.)

2. **Ptilothamnion pectinatum**, R. M. L. (? = *Callithamnion pectinatum*, Mont., Prodr. Phyc., p. 9). Plate XXIV., figs. 1 and 2.

Thallus minute, 3–6 mm. in length, and linear to linear-lanceolate in outline, oppositely distichously pinnate and sparingly bipinnated. Cells of rachis 30–50 μ in length and 15–25 μ in breadth. Pinnæ at the base of the rachis generally simple, from $\frac{1}{2}$–1 mm. in length, a pair springing from each cell. Towards the middle of the rachis they are sometimes compound. They occasionally branch dichotomously, and are provided with a pair of pinnules to each cell. The axils of pinnæ and pinnules are about 45°–60° measurement. The pinnæ consist of about 20 cells, about 30–40 μ in length and 10 μ in breadth. The pinnules are from $\frac{1}{4}$–$\frac{1}{2}$ mm. in length, with similar cells to those of the pinnæ. The tetraspores are in tetrads, terminal, and generally solitary at the ends of the pinnules; however, a second tetrasporangium is occasionally formed subsequently to the discharge of the first. The cystocarps are also terminal on the pinnules, the procarps being very similar to those described by Heydrich for *Ptilothamnion schmitzii*, and of very simple character. In some cases a second cystocarp is apparently formed close to the first, but I am not quite certain of this, as my specimens are somewhat entangled and in bad condition. The cystocarps apparently are readily detached, as I have not yet found a mature one in the position of the procarp, but they are always entangled among the pinnæ.

Distribution. — Auckland Islands (*Montagne*); Half-moon Bay, Stewart Island (*R. M. L., J. C. S.*): on a species of *Cladophora* (*? Cladophora colensoi*).

This is the first time this pretty little plant has been recorded since the voyage of the "Astrolabe" and "Zélée" in 1841. The identification is in the first place due to Agardh, to whom I sent specimens. He apparently regarded it as undoubtedly the same as Montagne's specimens, of which perhaps he may have had a type. The description of Montagne's plant, which may be given here for the sake of comparison, agrees well enough with mine, except as to the tetraspores: "*C. pectinatum* (Mont., Prodr. Phyc., p. 9). Microscopicum, filo primario repente pinnato, pinnis pinnulisque oppositis patentibus, articulis cylindricis diametro duplo longioribus aut æqualibus; tetrachocarpiis axillaribus."

The "axile tetraspores" (*tetrachocarpiis axillaribus*) does not agree well with the terminal tetraspores in my plant. Indeed, the New Zealand species seems to come close to the British *Ptilothamnion pluma* (see also under *Antithamnion ptilota*). I have, however, retained Montagne's specific name. This course is scarcely likely to cause confusion, and so it seemed unnecessary to describe the plant as new. I have therefore also accepted provisionally Agardh's identification.

Genus 3. GRIFFITHSIA (C. Agardh).

Thallus erect, pinnately or dichotomously branched. The branches are composed of single rows of large cylindrical cells, which are often expanded in the centre and constricted at the nodes, thus becoming cask-shaped. They are naked or provided with delicate ramuli arranged in whorls, which bear axile sporangia. These, in consequence of the obliteration of the point of the shoot, sometimes appear terminal, and the ramuli thus form an involucre consisting of fertile or partly of fertile and partly of sterile branchlets. The sporangia are divided into tetrads. The antheridia are thickly packed together or are arranged analogously to the sporangia tightly packed together or in somewhat loose bundles. Procarps terminal on special sometimes abbreviated or rudimentary branchlets, and developed out of 2 or 3 of the terminal joint cells of the shoot. The cystocarps terminal on shortened frequently quite abbreviated shoots, with an involucre of ramuli. The fruit-mass consists of 1 seldom of 2 gonimoblasts, collected into a single mass, or more generally divided into several successively developed gonimolobes. Almost all of the cells of the gonimolobes produce spores.

A genus of 20–30 species, found chiefly in the warmer seas. Typical species are *G. corallina* (C. Agardh), *G. setacea* (*G.* Agardh).

1. **Griffithsia sonderiana**, J. Agardh. Chief synonymy: *G. sonderiana*, J. Ag., Epicr. Florid., p. 62. *G. setacea*, Harv., Handbook of the N.Z. Flora, p. 709. *Callithamnion griffithsioides*, Harv., Phyc. Austr., pl. 160. *G.* (*?*), *comosa*, Grun. "Novara," p. 62, pl. x. Plate XXV., fig. 1.

The plant consists of masses of closely packed rather flaccid more or less irregularly dichotomous filaments. Dichotomy takes place about once every centimeter, or at every fourth or fifth cell. Branches fasciculated, fastigiate, 10–15 cm. long, and in dried specimens $\frac{1}{3}$ mm. in diameter. In fertile specimens below the apices appear a number of short lateral compound ramuli, more or less irregularly disposed, sometimes secund, at

other times dichotomous and fastigiate, in the axils and at the nodes of which the sporangia are formed. There is no involucre, but the sporangia are generally supported on a pedicel cell, and are at first solitary, though at length more are evolved at the side of the first. The lower cells of the branches are as much as twelve times as long as broad, the upper are about six times as long as broad. As in other plants of the genus, the cells when put into fresh water burst with a crackling sound and discharge their red colouring-matter. Cystocarps and antheridia unknown.

Distribution.—Australia, Tasmania; New Zealand—Riverton, The Nuggets, Port Chalmers, Moeraki, Oamaru, Lyttelton (*R. M. L.*); Green Island Beach, St. Clair, Warrington (*J. C. S.*); Chatham Islands (*Canterbury Museum*).

2. **Griffithsia antarctica**, Harv., Fl. Ant., vol. ii., p. 488; J. Ag., Epicr. Florid., p. 68. Plate XXV., fig. 2.

Fronds tufted, flaccid, rather sparingly branched, dichotomous, sometimes more or less irregularly pinnate towards the upper part; shorter, stouter, and much less tufted than *G. sonderiana;* from 8–12 cm. long, and about ½ mm. in diameter. Cells of the main axis 1200–1500 μ long and 400–500 μ broad. The fertile branches are somewhat inflated, and at length give off a short lateral branch, at the penultimate or antepenultimate cell of which a cuplike involucre is formed enclosing the tetraspores. The cells beyond this gradually become absorbed or disappear. The involucre consists of about 15 linear-oblong ramuli, enclosed at first in a corolla-like cup, but afterwards opening for the escape of the fasciculated tetraspores. In mature specimens the involucral cup frequently appears terminal on a single obconic cell, but at other times it is supported by a pedicel consisting of several cells. I have not been able to determine whether this difference is specific or only varietal. Antheridia and cystocarps unknown.

Distribution.—Tasmania; New Zealand—Akatore, Timaru, Taylor's Mistake (*R. M. L.*); Green Island, St. Clair, Warrington (*J. C. S.*); Foveaux Strait, Stewart Island (*Lyall*); East Coast (*Colenso*).

This plant may be readily distinguished from the preceding species by the very different arrangement of the tetraspores. Its generic position is uncertain. It may possibly belong to *Pandorea* or *Bornetia*, but until the cystocarps are discovered it should perhaps be left here. In *Pandorea* the ramuli surrounding the tetraspores cohere as in a gamopetalous corolla. In *G. antarctica*, according to Agardh, they are free, and this constitutes one of his chief diagnostic distinctions between the two.

genera. This distinction, however, appears to me to exist only when the two species are compared at different stages of growth.

Agardh thinks (Epicr. Florid., p. 69) that possibly two species differing only in their vegetative characters are included in this species—one closely resembling *Bornetia binderiana*; and this may turn out to be the case. The plant is not so common as *G. sonderiana*, and hitherto I have only obtained comparatively few specimens of it, and so am not in a position to say whether it really contains more than one species or not.

Genus 4. PANDOREA (J. Agardh).

Thallus irregularly dichotomously branched, of a single row of large cells, articulate, and in all respects similar to that of *Griffithsia*. Sporangia developed in special whorls of ramuli near the end of the shoot.* The branchlets of these fertile whorls are differentiated into short compound sporangia bearing ramuli, and into sterile one-celled covering ramuli, which are tightly locked together into a cup, enclosing the others, and reminding one of the corolla of one of the higher plants. These one-celled petaloid ramuli are from 30 to 40 in number. Antheridia and cystocarps unknown.

1. Pandorea traversii, J. Agardh. Plate XXVI.

The genus is monotypic. The number of parts in the cup surrounding the fertile ramuli, and the contiguity of the petaloid cells, serve at once to distinguish this species from the preceding, which it resembles much in other ways. It is, however, stouter, shorter, and much less branched than *Griffithsia antarctica*. Frond inclining to be erect, subfasciculate, axils of branches rather acute. The cells about two or three times as long as broad, and from $\frac{1}{2}$–$\frac{3}{4}$ mm. in diameter. The involucral cup is stuffed with very slender threads, bearing large tetraspores in tetrads. Antheridia and cystocarps unknown. The plant was first described by Agardh from specimens collected by Travers at the Chatham Islands.

Distribution.—Stewart Island, Taylor's Mistake, Lyall Bay (Wellington), (*R. M. L.*); Chatham Islands (*Travers*).

Genus 5. PLEONOSPORIUM (Naegeli).

Thallus upright, filamentous, repeatedly alternately pinnately branched with the pinnules decreasing in length towards the apex, more rarely dichotomously branched. Branches consisting of single rows of cells. Lower portion of the main shoot sometimes coated with rootlets. The sporangia are placed on

* *Vide* J. Ag., Florid. Morph., tab. i., figs. 1–8.

the upper pinnules of the thallus, and on the upper side of the pinnule: they are divided into numerous radially arranged spores. Procarps small, terminal, on the upper pinnules of the thallus, each with a single fertile cell. Cystocarps terminal, protected by a single lateral branchlet. Fruit-mass built up of 1 gonimoblast, divided into several rounded successively formed gonimolobes.

1. **Pleonosporium brounianum**, Harv.-Gibs. (= *Callithamnion brounianum*, Harv., Trans. Royal Irish Acad., xxii., p. 561). Plate XXVII., fig. 2.

Thallus dark-brown, 10–15 cm. high, irregularly alternately (more rarely oppositely) pinnately branched in all directions, with rhizoids descending along the whole length of the stem and branches from the basal cells of the pinnæ. The pinnules are long and filamentous, and the lower ones clothe the stem and branches with a matted mass of filaments, completely concealing the general branch system. The main rachis has comparatively few pinnæ, but the pinnæ are themselves pinnately decompound. In typical specimens the last series of pinnules at the tips of the branches are stout, more or less distichously corymbose and arcuate. In many specimens the apices are completely covered by filamentous pinnules growing up from below, which are prolonged beyond the growing-point in fastigiate masses. The axils of the terminal pinnules are acute, and the cells of which they are composed approximately square. As the frond is descended the axils become more patent, and finally the pinnules branch at an angle of from 60°–80°. The cells of the main stem are about 300–400 μ long and 100–150 μ broad. The cells of the pinnæ are of a similar type but rather smaller, of the pinnules very varied in relative dimensions. Those of the terminal pinnules are 40–50 μ long and 25–40 μ broad; but in the filaments cells may be obtained 150–200 μ long and only 25–40 μ broad. The sporangia are placed on the inner sides of the pinnules, rather sparsely at first. They are pear-shaped and undivided, but afterwards contain 8, 16, or 32 radially arranged spores, always more than 4 when mature. The cystocarps (according to Harvey-Gibson) are binate, terminal, and involucrate. Antheridia unknown.

Distribution.—Western Australia, Victoria (*Bracebridge Wilson*); Brighton, Dunedin (*R. M. L.*); St. Clair (*J. C. S.*).

This plant was first described from New Zealand by Professor Harvey-Gibson from specimens collected by Professor T. J. Parker (no locality given). As in the following species, the vegetative structure is that of *Spongoclonium*, but the sporangia fix it in the genus *Pleonosporium*. This plant may pos-

sibly not be specifically distinct from the following one, as both species seem to vary considerably, but they are distinct enough in their extreme forms.

Both plants require much fuller investigation and description than they have yet received.

2. **Pleonosporium hirtum**, R. M. L. (= *Callithamnion hirtum* (partim), Hook. and Harv., Fl. Antarctica, 192, t. 78, f. 2). Plate XXVII., fig. 1.

Thallus a dull purple-lake, tufted, 8 to 10 cm. high, irregularly alternately pinnately branched in all directions. Main stem often short or altogether wanting, the base sparingly coated with minute cells. Its articulations from 400–500 μ in length and 150–250 μ in breadth. It and the main branches are coated by decurrent rhizoids from the terminal cells of the pinnæ. The pinnæ are alternate and bi- or tri-pinnately branched, with cells intermediate in character between those of the rachis and terminal pinnules. The pinnules, excepting those near the apices, are long and filamentous, with cells of varying size and shape, and sometimes six to eight times as long as broad. These filaments are woven together into an inextricable network of small mesh covering about two-thirds of the entire surface of the plants, the ends of the pinnæ in older specimens alone being free from it. The plant is thus not so completely covered by the network as *P. brounianum*. The apices of the pinnules are free for the length of from 1–2 mm., and beset the plant on all sides, thus giving the plant that furry or shaggy appearance to which it owes its name. The apical pinnules often di- and sometimes tri-chotomously divided at their tips, and several often coalesce longitudinally to form a single branch. This perhaps gives rise to the veined appearance referred to by Harvey. The cells of these pinnules are from 60–80 μ long and 30–40 μ broad. Thev form penicillate masses completely surrounding and extending beyond the main growing-point. Sporangia of the *Pleonosporium* type, in series on the pinnules. Antheridia and cystocarps unknown.

Distribution.—St. Clair (*J. C. S.!*); Lyttelton (*R. M. L.*).

I am probably not wrong in identifying this plant with Harvey's *Callithamnion hirtum*, with which it corresponds exactly in general appearance and vegetative structure. Harvey, however, in his drawings shows tetraspores divided into tetrads; but this, I think, is to be explained by the fact that his species probably included not only *Pleonosporium hirtum*, *P. brounianum*, but perhaps also the *Spongoclonium* to which I have given the name *S. pastorale*. In my own collection there is a young plant bearing sporangia, collected at the same time and place as

older and infertile specimens. It is very different in appearance from them, for the rhizoids are undeveloped. After the sporangia are discharged the colourless cases remain behind, and apparently only gradually decay.

Genus 6. Callithamnion (Lyngbye).

Thallus upright, much dichotomised or laterally branched on all sides (or distichous in the upper part), with monopodial or sympodial arrangement. The branches consist of single rows of naked cells with more than one nucleus. The main branch frequently coated with rhizoids below. Sporangia in tetrads (sometimes cruciate according to some) on the upper branches of the thallus, attached laterally on the upper side (one or more on a single cell). Antheridia generally very small, consisting of thickly packed bundles of very various but analogous arrangement to that of the sporangia. The cystocarps attached laterally to the upper part of the thallus (more rarely apparently terminal), without an involucre, consisting of a pair of gonimoblasts (more seldom one), which put forth on a smaller central cell several successively formed rounded gonimolobes.

1. **Callithamnion byssoides,** Arnott (Harv., Fl. N.Z., ii., 260; J. Ag., Epicr. Florid., p. 29).

Thallus somewhat erect, alternately pinnately decompound, corticated at the base only, very flaccid, with the branches and branchlets coming out from all sides, the upper branchlets dichotomous and incurved, sublanceolate in outline, equal in length or shorter than the one on the inside. Tetraspores sparse on the inner side of the axils, the young ones obovate-clavate, ripe ones subrotund in tetrads. I have seen no description of cystocarps or antheridia, but the former at least are known.

Distribution.—The warmer Atlantic shores of Europe and America; Tasmania.

Var. **caulescens** (J. Ag., Epicr. Florid., p. 39), with a firmer stem which is corticated for a considerable distance upwards with decurrent threads enclosed in a membrane. Foveaux Strait and Otago Harbour (*Lyall*); Maketu (*Chapman*); Otago Harbour (*J. C. S.*).

The specimens I have seen, collected at the Maori kaik (Dunedin Harbour) by Mr. J. C. Smith, belong to Agardh's var. *caulescens*, which is probably a distinct species. The main axis and all the branches are corticated, the plumules alone being free. The articulations of the main stem and branches are thus completely hidden. The plant is 15–20 cm. high, irregularly alternately branched. The terminal pinnules are dichotomous, incurved, and subcorymbose at the tips. The lower portions of

the stem and main branches are not provided with pinnules, the tips of stem and branches are thus rather plumose. The cells of the pinnules are from 150–180 μ long and about 30–40 μ broad. The cells of the cortex vary much in their dimension, and are from two to four times as long as broad. I have seen no reproductive organs on this plant.

2. **Callithamnion colensoi**, Harv., Fl. N.Z., ii., 259. Plate XXVIII., figs. 1*a*, 1*b*.

Frond dark-purple, robust, dendroid, 2–3 in. high. Main stem as thick as a sparrow's quill below, internodes coated with small cells, laterally branched; branches densely clothed all round with minute compound squarrose imbricated ramuli; ultimately divaricate, subulate-acute, alternate; articulations coated with small cells, one and a half times longer than broad, ultimate pellucid.

Distribution.—East Coast and Hawke's Bay (*Colenso*).

I have a fragment of a plant on a microscope-slide which probably belongs to this species. It was collected at the Nuggets. Unfortunately, I do not seem to have any mounted specimens of it. The rachis and pinnæ are alternately branched, lanceolate in outline, and each of the younger pinnæ is developed inside a membrane, from which it finally escapes. This is evidently a highly characteristic feature of the plant. The ramuli are compound, and from 80–100 μ in length. The cells composing them are minute and approximately square, with a length of 15–25 μ. The tetraspores are arranged along the pinnules in some cases in two, three, or four longitudinal rows, but in other cases no orderly arrangement can be made out. They are developed in the axils of the ramuli, which clothe the whole plant in the manner described above, *i.e.*, "with minute compound squarrose imbricate branchlets." The ramuli bear divaricating processes, which are sometimes secund, and at other times irregularly alternate and dichotomous. The plant is completely corticated with small cells. Articulations of the ultimate pinnules are about twice as long as broad.

3. **Callithamnion consanguineum**, Harv., Fl. N.Z., ii., 295.

Fronds densely tufted, flaccid, rose-purple, 2–3 in. high, capillary, excessively branched; branches spreading, the smaller distichous above, alternately decompoundly pinnate and alternately plumulate; plumules short, flabellate, naked below, pinnate above, terminal; pinnæ close-set; articulations opaque, with cortical cells two to three times as long as broad; upper pellucid. Tetraspores lateral, subsolitary, triangularly divided.

Distribution.—Port Nicholson (*Lyall*); the Esplanade (Wellington), Petone (*R. M. L.*).

I have specimens, which agree exactly with the above description (Harvey's), from Wellington Harbour, but I have not seen tetraspores, cystocarps, or antheridia. The plant has not been recorded hitherto since collected by Lyall.

Genus 7. Spongoclonium (Sonder).

Thallus upright, rounded, provided with unequally long similarly branched pinnæ on all sides. These produce filamentous pinnules, which form a spongy network covering the plant. The lower cells of the pinnæ send out rhizoids, which, becoming decurrent, clothe the main stem and branches with a gradually thickening covering. Sporangia shortly stalked, and divided into tetrads attached singly or in series to the free ends of the pinnules. Antheridia in closely packed tufts, similarly arranged to the sporangia. Cystocarps scattered over the surface of the thallus in large numbers, terminal on branches so short that they appear seated on the network of the thallus. The thallus filaments are more richly developed under the cystocarps, so as to enclose them on the underside, but there is no cuplike involucre. The spore-mass consists of 1 gonimoblast, which divides into numerous successively formed rounded very small gonimolobes. Gonimolobes tightly closed with all cells giving rise to carpospores.

(The cystocarps are unknown or insufficiently described in the New Zealand species, but there can be but little doubt that they are rightly inserted here.)

1. **Spongoclonium pastorale**, sp. nov. (R. M. L.). Plate XXVIII., fig. 2.

Thallus dark-brown, sometimes blackish, 3–6 cm. high, irregularly alternately pinnate. Main branches rather few, flexuose. Rachis and pinnæ coated with decurrent rhizoids. Pinnules flexuose, woven into an inextricable network. Terminal pinnules patent, often divaricating, subdistichous (though 3 or 4 occasionally arise from one cell), sparingly branched, but sometimes bearing pectinate ramuli on the upper side. The ends of the pinnules often crooked like a shepherd's staff, or sharply bent. Cells of pinnules about 80 μ long and 50 μ broad, of the axis about 200 μ long and 60–80 μ broad, those of the pinnæ similar but rather smaller. Tetraspores numerous in series on the pinnules, divided into tetrads. Cystocarps and antheridia unknown.

Distribution.—Wycliffe Bay (Otago Peninsula), (*R. M. L., J. C. S. f.*).

2. **Spongoclonium brachygonum**, R. M. L. (? = *Callithamnion brachygonum*, Harv., Fl. N.Z., ii., 259). Plate XXIX., fig. 1.

Thallus 6–8 cm. high, dull-red, densely tufted, without apparent main stem or branches, irregularly alternately pinnately decompound. The pinnules are long interlacing filaments which cover the whole plant with a somewhat open network, but become shorter near the apex in acropetal succession. The terminal pinnules are more or less distichous, but occasionally secund. The plant bears some external resemblance to *Pleonosporium brounianum* and *P. hirtum*, but it is much more slender and delicate than either, and the network of pinnules, though more open than in either of the other two, covers it more completely. The pinnules at the apices are much more open and loose than in *P. hirtum*, and much longer and not flabellately expanded as those in *P. brounianum*. Tetraspores solitary, lateral, rather sparse, divided into tetrads. (For cystocarps see below.)

Distribution. — Purau (Lyttelton), Wellington (*R. M. L.*); Warrington (*Berggren*).

I have seen a distinct variety or possibly a new species collected by Mr. Cresly Smith at St. Clair, but in the absence of more material I hesitate to describe it. It may possibly be the true *S. brachygonum*, for it possesses the rod-like branchlets referred to by Harvey, which this plant does not. However, my plant was originally determined by Agardh, and I translate his remarks on the species in reference to some specimens obtained by Berggren at Warrington*: "I have seen no plant of Harvey's. With great hesitation I refer to this species a little plant about an inch in length gathered at Warrington by Berggren. It is certainly a *Dasythamnion* with the stem clad with decurrent filaments. Harvey has not a word about this character. The branches are pinnately elongated, subcorymbose at the apex, with rather dense incurved ramuli. The pinnæ are decussate below, with the pinnules lateral or extrorse, all patent or somewhat erect, and rather obtuse curved over the apex. Cells of the pinnæ twice as long as broad, of the pinnules half as long again or equal. Twin cystocarps of the usual rounded form below the apex of a pinna."

It will be seen that Agardh's description differs in various points from mine, but in his determination of my specimens he seems to me to have confused under the title *C. brachygonum* plants of *P. hirtum* and *C. brachygonum*. Hence I scarcely feel justified in relying upon his identification of *S. brachygonum* with Harvey's *C. brachygonum*. I therefore transcribe from the

* De. Alg., N.Z., Mar., p. 13.

Flor. N.Z., ii., p. 259, Harvey's description, as some future investigator may meet with a plant which agrees with it more closely than this does. Should this prove to be the case, I would suggest that this be described as a new species under the name *S. agardhii*. I have deposited specimens of what seem to me to be typical forms of this and of the species of *Pleonosporium* in the Canterbury Museum, and as they are quite distinct any subsequent worker in New Zealand will readily be able to determine whether any similar form he may find agrees with them or not.

Callithamnion brachygonum,* Harv., Fl. Nov. Zel., ii., p. 259.

" 1 or 2 in. high, densely tufted, flaccid, bright carmine-red. Stem subsimple, set on all sides with lateral similar branches, which bear a second or third series of similar rod-like branchlets, the last series of which are clothed with subdistichous plumules. Plumules very narrow, erect, patent, the lower most simply pinnate, the upper gradually longer and more compound, those near the middle of the branches very long and bipinnate. All the articulations are short, those of the stem and branches veinless with narrow endochrome and thick walls. Tetraspores line the inner faces of the ramuli."

Genus 8. Euptilota (Kuetzing).

Thallus erect, very richly distichously branched, flattened on both edges, coated with rhizoids in the lower part or nearly to the top, or enclosed in a more or less thick normal cortex throughout its whole length. Shoots of two kinds, (*a*) of limited (*b*) of unlimited growth. Those of unlimited growth are alternately pinnate with entirely or alternately pinnatifid or alternately pinnately compound or decompound limited branches, of which some develop into unlimited branches. Apical cell of the unlimited branch diagonally segmented. Sporangia in the upper part of the thallus on short articulated naked stalks, which shoot out singly or in groups, or are united into branched bundles, upon the edges (especially the upper edges) of the limited pinnæ. Antheridia (as far as is known) small stout bundles of branches growing out of the edge of the limited pinnæ. Procarps on short pinnæ, or on the teeth of the pinnæ of somewhat enlarged limited shoots near the point. Cystocarps terminal on the short fertile pinnæ, sometimes apparently laterally placed, enclosed by more or less numerous subsequently developed involucral ramuli.

The typical species is *Euptilota formosissima* of New Zealand.

* I have adopted the description given in the Flora in preference to the translated description of the Handbook, as the former appears to me to be the more intelligible of the two.

1. **Euptilota formossissima**, Kuetz. (= *Ptilota formossissima*, Mont., Prodr. Phyc. ant. p. 8.; Harv., N.Z., ii., 257; Fl. Antarct., 190, t. 77; J. Ag., Epicr. Florid., p. 79).

Thallus 20–30 cm. long, pinnately decompound, with the pinnæ alternate, the pinnules pinnatifid, and the whole plant completely corticated to the apex; the ultimate pinnules are serrate, with the serrations gradually growing narrower from a somewhat broad base to an acute or mucronate apex. Tetraspores triangularly divided, numerous on the teeth, on a scarcely conspicuous articulated pedicel amongst similar not fertile filaments. Cystocarps enclosed in corticated pinnatifid ramuli. Antheridia unknown (?).

Distribution.—Common on the New Zealand coasts; Chatham Islands.

This is a well-known and very handsome species. The pinnæ are as described for the genus, of two kinds, limited and unlimited in growth. Those of limited growth are more than ten times more numerous than those of unlimited growth, which seem to be placed irregularly, but generally give the plant the appearance of being more or less flabellately decompound. The pinnæ of limited growth are from 4–8 mm. in length.

2. **Euptilota pellucida**, R. M. L. (= *Ptilota pellucida*, Harv., Fl. N.Z., ii., 257; J. Ag., Epicr. Florid., p. 75). Plate XXIX., fig. 2.

Thallus 8–12 cm. in length, roughly ovate or elliptical in outline, distichously oppositely pinnately decompound, with pinnæ of limited and unlimited growth, but branching more regular than in *E. formossissima*. The main stem and bases of chief pinnæ only corticated; and the cortication much less dense than in *E. formossissima*. The articulations of pinnæ and pinnules naked. The last series of pinnules pectinate, or pinnate and the opposite ones often unlike, one being more or less undivided and the other much divided. The pectinations are either on the upper or lower side of the pinnule, and are filamentous and subulate. The apical cells of the pinnæ of unlimited growth are diagonally segmented. The tetraspores are lateral, solitary, sparse, with short pedicel, or often apparently sessile, and cruciately divided.

Distribution. — Otago, Stewart Island (*Lyall*); St. Clair (*J. C. S.*); Lyall Bay (*R. M. L.*).

A much less common plant than the preceding, and of much more delicate structure altogether. Its position seems to me to be uncertain. Agardh places it in his division of the genus: "Pinnis oppositis, utraque pagina conformi, magnitudine aequali aut una majore," and in his description of the species says the

pinnæ are opposite and similar ("pinnis in rachide filiformi oppositis conformibus"); but Agardh is here in error—the pinnæ are almost invariably unlike. Further, Agardh had not seen the tetraspores: their method of division, and the fact that they are often sessile, may place this plant outside the group *Ptiloteæ* altogether. Perhaps, however, until the cystocarps are known, and its position thus made more definite, it may be provisionally retained here. The segmentation of the apical cell of the unlimited pinnæ places it in the genus *Euptilota* rather than in the genus *Ptilota*. Agardh states that it is parasitic on *Hymenocladia*. I have found it more often epiphytic on *E. formossissima*, but also on other plants.

Genus 9. Ballia (Harvey).

Thallus upright, filamentous, richly generally distichously branched. Main axis of a single row of cells, with opposite (seldom whorled) simply or compoundly pinnate similar or alternately unlike pinnules, covered below with a thickly woven felt consisting of branched filaments which grow out of the bases of the pinnules, also frequently coated in the lower parts with rhizoids which tightly enclose the main axis. Sporangia cruciate or in tetrads, terminal on the pinnules of special generally irregularly branched basal pinnules. Antheridia (so far as is known) in small stout loose bundles on the points of the ultimate pinnules. Carpogonium bearing branch, four-celled, slightly bent, solitary, fastened to the basal cell of a few elongated pinnules. Fertile pinnules distributed over the plant, mostly on the shorter thallus branches. The auxiliary cell is developed from the fertilised cell of the carpogonium branch. Cystocarps generally developed in rows on the axil of a somewhat elongated very shortly stalked pinnule, enclosed as by an involucre by the subsequently developed richly branched basal pinnules of the fertile shoot. There is a single gonimoblast which develops into several or numerous rounded gonimolobes.

1. **Ballia callitricha**, J. Ag., Syst., p. 166 (= *Ballia hombromana*, Mont., Voy. au Pole sud, t. 12, f. 1. *Ballia brunonis*, Harv., Fl. Antarct., 182. *Ballia callitricha*, J. Ag., Epicr. Florid., p. 58).

Root a spongy disc. Thallus densely tufted, 4–20 cm. in length, with stout rigid stupose stipes, distichously pinnately decompound, with the pinnæ and pinnules opposite, similar, and lanceolate in outline, and very closely set, with the last series simple and more or less acute.

The following varieties, dependent on age, are distinguished by Agardh: (*a*) *normalis*, with the pinnæ very densely decompoundedly pinnate, pinnules plumose; (*b*) *pennata*, with the

pinnæ very thickly pinnate, the pinnules simple; (*c*) ***simplicipilum***, the branches rather laxly pinnate, the pinnæ filiform, elongated.

Distribution.—Common on the east coast of the South Island, and probably elsewhere in New Zealand. Auckland and Campbell Islands (*Harv.*); Macquarie Islands (*A. Hamilton*); Australia, Fuegia, Falklands, Kerguelen, &c.

The minute structure of the plant has been described by W. Archer in a paper read before the Linnæan Society on the 15th June, 1876. In every joint-cell of the plant there occurs in the dissepiment a minute "pit," which is afterwards closed by a "stopper." In a "sinus" placed laterally on the joint-cells is formed a special cell, called by Archer a "ramification cell," which is either pentagonal or hexagonal. This becomes inflated towards the upper end, which is finally cut off by an oblique septum, and this cell becomes the first joint of a simple branch or subsidiary rachis. "The lower portions of the main stems are covered all round by a single layer of thick-walled elongated cells, mutually closely apposed, of variously irregularly curved and crooked figure. . . . This cortical stratum of cells somewhat resembles a kind of pleurenchymatous or prosenchymatous tissue." The development of this tissue is also traced back to ramification cells. The cortical cells themselves are also repeatedly dichotomous, and give rise to a considerable portion of the accessory filamentous investment of the plant. Many of the filaments, however, are developed from subsidiary ramification cells, or from cells adjacent to them. For a full understanding, however, of the complicated structure of the plant reference must be made to Professor Archer's paper. I have given this very short account of its development, however, as it seemed to me that the generic description of Schmitz given above was perhaps somewhat misleading.

2. **Ballia scoparia**, Hook. and Harv., Lond. Journal, iv., p. 173 (= *Callithamnion scoparium*, Fl. Nov. Zel. ii., p. 259. ***Ballia scoparia***, J. Ag., Epicr., p. 59; Harv., Phyc. Austr., t. 168. *Rhodocorton parkeri*, Harvey-Gibson, Journ. of Bot., 1893, p. 161). Plate XXX., fig. 1.

Thallus 10–20 cm. high; frond spreadingly branched, with branches coming off in all directions and covered on all sides with fasciculate decompound appressed ramuli. The stem and root similar to that of *B. callitricha*, stupose. The terminal pinnules near the apices of the fascicled ramuli, subsecund, acuminate, and furnished with 2 or 3 lateral spines. The sporangia are terminal on the pinnules, or lateral and subsecund, cruciately divided. Joint-cells about half as long again as broad.

Distribution.—Common along the coast of the South Island, and probably elsewhere; Australia, South America.

I have examined one of Professor Harvey-Gibson's type specimens of *Rhodocorton parkeri*, and I have no hesitation in saying that it is a very young specimen of this plant. The spines, which, according to Professor Gibson, in his plant "form the most characteristic and diagnostic feature of the species," are equally characteristic of *B. scoparia*. The segmentation of the cells is that of *B. scoparia*, and not of a *Rhodocorton*. The arrangement and division of the tetraspores is the same in each. Specimens of each are indistinguishable in their appearance under the microscope; the relative dimensions of the cells are the same, and rhizoids are developed similarly on both. *Rhodocorton parkeri* was found at the base of a thallus of *Lychaete darwinii*.* *Lychaete darwinii* and *Ballia scoparia* are found so frequently epiphytic one upon the other that their constant companionship seems almost to suggest commensalism. Apparently, then, there is every reason for regarding *R. parkeri* as merely a synonym for *B. scoparia*.

Genus 10. Antithamnion.

Thallus filamentous, generally dichotomously branched with sympodial growth. The main axis consists of single rows of cells with opposite or whorled generally richly branched ramuli. On the branches of the ramuli are often formed peculiar gland-cells. The sporangia are terminal on the branches of the ramuli, and divide cruciately. The antheridia are small bundles of branches terminal on the ultimate branch of the ramulus. Fertile ramuli are distributed over the shoot or collected in bundles close to its end. The development of the terminal cells is then arrested. The cystocarps thus become nearly terminal or apparently terminal. They are enclosed as with an involucre by the uppermost sometimes subsequently developed ramuli. In some species the sporangia-bearing plants develop paraspores in few- or many-celled irregular masses at the point of the shoot.

1. Antithamnion applicitum, R. M. L. (= *Callithamnion applicitum*, Harv., Fl. N.Z., ii., 258). Plate XXX., fig. 2.

Thallus minute, investing the surfaces of other algae but not completely attached to them. Fronds 2–3 mm. in height, partially erect, nearly regularly oppositely pinnately distichously branched. A pair of pinnæ spring from below the apex of each cell and from opposite sides of it: these are generally compound, sometimes decompound. The pinnules are arranged similarly to the pinnæ, and both pinnæ and pinnules consist of

* Laing, Trans. N.Z. Inst., vol. xxvii., p. 300.

from 6–10 or occasionally more cells. Sometimes one row of pinnules is wanting or partially wanting: this is particularly the case at the apices of the thallus. Cells of rachis one and a half times to twice as long as broad, and from 100–150 μ in length. The pinnæ are about $\frac{1}{2}$–$\frac{2}{3}$ mm. in length, though occasionally they are several times that length. The cells of the pinnæ are three or four times as long as broad, and rounded at the apex. The cells of the pinnules are about one and a half times as long as broad, and the pinnules themselves about $\frac{1}{4}$–$\frac{1}{3}$ mm. in length. The apical cells extend slightly beyond the pinnules in my specimens. In southern specimens these cells are acute, but in some from Wellington they are rather obtuse. Axils acute, and pinnæ sometimes curved. As in the allied species, the basal cell of each pinna is generally small and without pinnules. Tetraspores cruciate, probably solitary in the axils of the pinnules. Antheridia unknown. Cystocarp unknown.

Distribution.—Riverton, St. Clair (*J. C. S.*); Green Island Beach, Western Heads (Wellington), (*R. M. L.*).

I have seen no type specimens of this plant, and Harvey's original description is very imperfect, so that identification with absolute certainty is impossible; but this can scarcely be anything else than Harvey's *C. applicitum*, although my specimens are not completely attached to the other algæ on which they are epiphytic.

2. Antithamnion adnatum, R. M. L. (= *Callithamnion adnatum*, J. Ag., de Alg. N.Z., Mar., p. 12). Plate XXXI., fig. 1.

Thallus minute, at first creeping but afterwards nearly erect, 2–4 mm. in length, oppositely bi- and occasionally tri-pinnate. Each cell of the frond provided with 3 or 4 pinnæ (more rarely 2) arranged in rows. The plant is thus largely tri- or tetra-stichous. Cells of the rachis about 150–180 μ in length and 50–60 μ in breadth. The pinnæ are generally simple (about $\frac{1}{4}$ mm. in length), and consist of 12 to 15 or occasionally more cells, which are in length about 80–100 μ, and in breadth about 40–50 μ. A group of pinnæ come off from below the apex, and curving over it completely enclose it. The pinnæ are more or less arcuate, and the axils acute, so that their tips are generally in contact with the main rachis. Pinnules short, with cells about one and a half times as long as broad, or approximately square. Organs of reproduction unknown.

Distribution.—Bay of Islands (*Berggren*); Lyall Bay, Pukerua (*R. M. L.*); Riverton (*J. C. S.*).

In the absence of cystocarps and tetraspores the exact position of this plant is doubtful, but its vegetative structure is that of *Antithamnion*.

3. Antithamnion ptilota, Harv.-Gibs. (= *Callithamnion ptilota*, Hook. and Harv., London Journal, iv., p. 272).

Frond somewhat rigid, setaceous, with rather erect very densely branched pinnate filaments, the pinnæ nearly distichous, veined, with opposite pinnules. Pinnules simple, patent, subulate. Tetraspores sparingly on the pinnules. Cystocarps and antheridia unknown.

Distribution.—Crozets (*Harvey*); New Zealand (*T. J. Parker*).

This plant is recorded from New Zealand by Professor Harvey-Gibson in a paper "On some Marine Algæ from New Zealand" ("Journal of Botany," 1893). I have also a plant from Half-moon Bay, Stewart Island, which Major Reinbold determined as a young specimen of this species, but it is the same as the plant determined for me by Agardh as *C. pectinatum* (vide supra, *Ptilothamnion pectinatum*), and it seems to me that it agrees with the description of *C. pectinatum* better than with that of *A. ptilota*. Further, it has tetraspores in tetrads, and according to Agardh they are cruciate in *A. ptilota*, but in tetrads in *A. pectinatum*. Harvey-Gibson's plant bore tetraspores, but he does not say of what sort, and I have not seen the original description of Harvey's of *A. ptilota*. The tetraspores in *A. ptilota*, according to the figure in the "Flora Antarctica" (tab. 189, fig. 1), are lateral, not terminal. Considering these differences, I do not think the plant determined for me by Major Reinbold as *A. ptilota* can be assigned to that species.

4. Antithamnion mucronatum, R. M. L. (= *Callithamnion mucronatum*, J. Ag., Ep., vol. ii., p. 29; Harv., Phyc. Austr. Syn., No. 688. *C. cruciatum*, Harv. in Lond. Journ., iii., p. 449).

Thallus 10–15 cm. high, robust, irregularly pinnately alternately decompound, the whole covered with opposite di- tri- or tetra-stichous patent and generally retroflexed ramuli, which are much more crowded towards the apices of the stem or branches. The ramuli are compound or decompound, and provided usually with 4 to 6 short branchlets, and all singly or doubly mucronate. Tetraspores cruciately divided, secund on the upper sides of the ramuli. Cystocarps and antheridia unknown.

I have seen no specimens equalling in dimensions those described from Tasmania,* which are more than 1 ft. in length. Most of my specimens are tetrastichous, and distichous only when young, and I have seen nothing of the woolly filaments enclosing the base of the stem described by Harvey,† nor have I noticed the ocellated apex described for the younger specimens by Agardh.‡ However, there can be no doubt as to the authen-

* Fl. Tasm. ii. 334. † *Loc. cit.* ‡ Epicr. Florid., p. 19.

ticity of the species, as I have compared it with fragments of Harvey's original plants, with which it agrees well; and my own specimens were first identified by Agardh. I have, of course, given a description of the plants as they are found in New Zealand, and I have not adopted Agardh's or Harvey's descriptions, which were drawn up from Australian and Tasmanian specimens. The following measurements may assist in identification: Cells of rachis 500–600 μ long and 300–400 μ broad. The ramuli are from 600–800 μ long, and contain 7 to 10 cells of about 60–90 μ in length, and in breadth 30–40 μ.

5. **Antithamnion plumula**, Thuret (= *Callithamnion plumula*, Hook. and Harv., Fl. N.Z., ii., 258; J. Ag., Epicr. Florid., p. 24; Ellis, Phil. Tr. 57, p. 426).

Frond flaccid, rose-red, spreading and densely opposite pinnate, 5–15 cm. in height, the pinnæ distichous or tetrastichous, horizontal or sometimes upwardly recurved, with pectinate pinnules. In luxuriant specimens the pinnules are furnished with an additional row of pectinate subpinnules, and these again may be pectinated. Joint-cells of the axis three or four times as long as broad. The cruciately divided tetraspores in fertile specimens replace the ultimate pinnules. I have seen no description of the cystocarps or antheridia.

Varieties: (*a*) plumula, distichously pinnate, with the rachis and pinnules subparallel; (*b*) investiens, tetrastichously verticillate, with the pinnules flexuose and diverging, and enclosing the apical portion of the stem.

I have seen no specimens of the form *plumula*. Agardh, however, returned some specimens collected by Mr. Crosby Smith at St. Clair as *A. plumula*, var. *investiens*. This plant is epiphytic and somewhat sparingly branched, and from 1–2 cm. in length. The pinnules are apiculate and often retroflexed. To me it appears much more like a variety of *A. mucronatum* than of *A. plumula*. Agardh, speaking of the Australian form,* says that it may be a distinct species, but that he is unable to find any good distinctive characters.

Distribution.—D'Urville Island (*Lyall*); var. *investiens*, St. Clair (*J. C. S.*); Atlantic Ocean, Mediterranean, Australia, Fuegia.

6. **Antithamnion flaccidum**, R. M. L. (= *Callithamnion flaccidum*, Hook. and Harv., Fl. N.Z., ii., p. 258; J. Ag., Epicr. Florid., p. 20).

Thallus flaccid, 5–10 cm. long, pinnately decompound, with the larger branches and pinnæ similar and lanceolate in outline,

* Epicr. Florid., p. 25.

oppositely pinnulate, the lower and upper pinnules of the pinnæ somewhat simple, patent, and obtuse, the middle ones compound, with the upper branchlets secund. Cells of the rachis six times longer than broad. Tetraspores in tetrads (?), secund on the pinnules.

Distribution.—Otago Harbour (*Lyall*); Fuegia, Tasmania.

I have seen two plants of this type, one from Riverton and one from Port Chalmers, but I cannot identify either with any certainty as belonging to this species, nor am I satisfied that the plant described by Agardh is the same as Harvey's.

7. Antithamnion (?) confusum, R. M. L. (= *Callithamnion confusum*, J. Ag., Epicr. Florid., p. 25. *Wrangelia squarrulosa*, Harv., Fl. Nov. Zel., ii., p. 236. But not Alg. Austr. exs. No. 266.)

Thallus erect, 15–25 cm. high, with rather lax irregularly alternately pinnate branches, the lower pinnæ spreading, the upper distichous with acute axils. Each node provided with whorled ramuli: two lateral ones divaricating, compound, pectinate, the branchlets of the ramulus diverging, cuspidate, often reflexed, the outer branchlets sometimes dichotomous at the tip; two smaller ramuli, often very much reduced, sometimes represented only by a hook-like process, are found alternating with the others. The ramuli do not spring directly from the node, but from a short distance below it, and are connected with it internally by a thread of brightly coloured protoplasm. Towards the base of the plant the internodes of the main axis and pinnæ are completely invested by the ramuli, which are here larger and more decompound, with many of the branchlets more or less appressed to the stem. I have only seen several sporangia, which were transversely divided into two, and, unless divided again in the plane of the slide, contained only two spores. Antheridia and cystocarps unknown.

Distribution.—Preservation Harbour (*Lyall*); Catlin's, St. Clair (*J. C. S.*); Wycliffe Bay, The Nuggets (*R. M. L.*).

The position of this plant is uncertain, and must remain so until the cystocarps are discovered. Harvey placed it in the genus *Wrangelia*. Agardh considers that its vegetative structure suggests rather the genus *Callithamnion* than *Ptilota* or *Wrangelia*. I believe that its place will be found in the genus *Antithamnion*, for it is well provided with the gland-cells (?) so characteristic of that genus, and the probably immature spores which I have seen suggest *Antithamnion* rather than *Callithamnion*. It is, moreover, very similar in structure to such a plant as *A. mucronatum*. There can be but little doubt of the identity of my plant with Harvey's, but it is possible that it is not the same as

Agardh's *Callithamnion confusum*. He states that he has seen "supra axillas quasi in gelatina effusa globos sphaericos plurimos nidulantes in quibus forsam initia antheridiorum credere licet." Is it possible that he here refers to the gland-cells ?

8. Antithamnion ternifolium, R. M. L. (= *Callithamnion ternifolium*, Hook. and Harv., Lond. Journ., iv., p. 272; Flora Antarct., p. 489, tab. 189, fig. 2). Plate XXXI., fig. 2.

Thallus erect, forming dense tufts 2–4 cm. high, attached in my specimens by holdfasts to *Macrocystis*, rather irregularly dichotomously or pinnately branched, extremely slender and flaccid, the lower branches distant but becoming crowded towards the tip. Ramuli di- tri- or tetra-stichous, perhaps most frequently in threes, often dichotomous, flagellate, acuminate, consisting of 12–15 cells. Tetraspores cruciate, sparse, in the axils of the branches. The cystocarps are solitary and surrounded by a large number of involucral ramuli. The cells of the main stem 0·5–0·75 mm. long and 0·1–0·15 mm. wide, about five times as long as broad; cells of ramuli about twice as long as broad, and becoming rapidly narrower towards the long acuminate almost hair-like point.

Distribution.—On *Macrocystis pyrifera* at Timaru, in dense matted tufts (*R. M. L.*).

This plant has hitherto only been known from the neighbourhood of Magellan Straits. I procured specimens of it at Timaru and forwarded it to Major Reinbold, who identified it provisionally with *Callithamnion ternifolium*, Hook. and Harv., and this identification must hold unless it can be shown definitely that the plant is new. The specimens are much more luxuriant than those of Hooker and Harvey. Their specimens, however, were dredged, and seaweeds growing in deeper water are often dwarfed. The original description is so brief as to be almost insufficient for purposes of identification. The plate given in the "Flora Antarctica" is also not altogether satisfactory, the tetraspores being shown in one place as in tetrads, whilst another figure suggests cruciate division. The cystocarps are stated to be terminal on the branches in the "Flora Antarctica" (*loc. cit.*). It is not very clear what is here meant by a branch. In accordance with the generic character the cystocarps are perhaps formed at the end of the ramulus, but they are not terminal on the main stem and branches, and they become so surrounded by the involucral ramuli when fully developed that it is not easy to determine their original position. They are not two-lobed, although two are often developed close to each other. I have therefore had to rely upon the vegetative characters in determining the species. This agrees well with those described

and figured for *Callithamnion ternifolium*. Too much stress, however, must not be laid upon the occurrence of the ramuli sometimes in threes, for this is a common character in the genus (*e.g.*, *A. adnatum*, *A. cruciatum*). The flagellate often once dichotomised hairlike acuminate ramuli, perhaps, therefore, in the present state of our knowledge, provide the best diagnoses for the species. Hariot mentions the plant (No. 110) in his list of seaweeds from Cape Horn, but gives no description.

(Other species of *Antithamnion* occur in New Zealand, but they have not yet been obtained in sufficient quantity for satisfactory determination.)

EXPLANATION OF PLATES XXIV.–XXXI.

Plate XXIV.

Fig. 1. *Ptilothamnion pectinatum*, R. M. L. (Mont.): Part of frond, showing tetraspores in tetrads (× 130).

Fig. 2. Part of frond, showing cystocarps in various stages (× 130).

Plate XXV.

Fig. 1. *Griffithsia sonderiana*, J. Ag.: Tip of branch, showing young undivided tetraspores (× 85).

Fig. 2. *Griffithsia antarctica*, Harv.: Showing involucral cup with escaping tetraspores (× 45).

Plate XXVI.

Pandorea traversii, J. Ag.: Tip of branch, showing involucral cup with escaping tetraspores (× 45).

Plate XXVII.

Fig. 1. Tip of frond of *Pleonosporium hirtum*, showing young, mature, and empty sporangia (× 85).

Fig. 2. Tip of frond of *Pleonosporium brounianum*, Harv.-Gibson (Harv.), (× 85).

Plate XXVIII.

Fig. 1. Tip of frond of *Callithamnion colensoi*, Harv., with tetraspores.

Fig. 1*a*. Small portion of ultimate pinnule of the same (× 270).

Fig. 2. Tip of frond of *Spongoclonium pastorale*, R. M. L., showing division of tetraspores and (*a*) a mature tetraspore escaped from the sporangium (× 130).

Plate XXIX.

Fig. 1. Tip of thallus of *Spongoclonium brachygonum*, R. M. L. (Harv.), (× 100).

Fig. 2. Tip of thallus of *Euptilota pellucida*, showing cruciate tetraspores (× 130).

Plate XXX.

Fig. 1. Small portion of pinna of *Ballia scoparia*, Harv., showing characteristic spinous processes at the tips of the pinnules (× 66), for comparison with *Rhodocorton parkeri* (Harv.-Gibson).

Fig. 2. Portion of a pinna of *Antithamnion applicitum*, R. M. L. (J. Ag.), (× 85).

Plate XXXI.

Fig. 1. *Antithamnion adnatum*, R. M. L. (J. Ag.): Tip of the pinna (× 340). (The pinnules should be more fastigiate and less divaricating.)

Fig. 2. *Antithamnion ternifolium*, R. M. L. (Harv.): Tip of frond (× 340).

ART. XLIII.—*On the Pollination of the Puriri* (Vitex lucens, *T. Kirk*).

By D. PETRIE, M.A.

[*Read before the Auckland Institute, 4th July, 1904.*]

THE puriri is a well-known beautiful and valuable tree that grows throughout the lowland parts of the Auckland Province, and extends as far south as Mahia Peninsula on the east coast and Cape Egmont on the west.

Its chief time of flowering is in the winter, though stray flowers may be found at most seasons of the year, and trees may always be found in full bloom during the months of May, June, July, and August. The flowering season of single trees often extends over two months or more, and it is no uncommon thing to see full-grown fruit and young flowers on the same branch, and even on the same panicle.

The flowers grow in spreading flattened axillary panicles among the upper or younger leaves. Those borne in a panicle vary in number from four to twelve, and are supported on rather slender but fairly rigid flower-stalks. The flowers are of fair size, being about an inch in length and nearly an inch wide in front.

The calyx is short and cup-shaped. The corolla, which is pink or more usually dull-red in colour, is tubular and irregular, with a four-lobed limb. The upper lobe or lip is comparatively short, slightly arched, and either entire or bifid. The lower-lip is much larger and broader, strongly deflexed, and trifid.

The stamens, four in number, spring from the lower part of the corolla-tube, and have long filaments. The bases of the filaments and the parts of the corolla between their points of insertion are densely clothed with a felted mass of long hairs that completely blocks the tube of the corolla leading down to the ovary.

The pistil consists of a short subconical ovary, situated below the level of the bases of the filaments, and of a long and fairly stout polished style, terminating in two (rarely in three) short divergent style-branches. The stigmatic surfaces are confined to the extreme tips of the style-branches, and are not larger than the head of a pin. Where the style joins the ovary there is a shallow constriction, and it is this groove that secretes most, if not all, of the abundant nectar that bathes the ovary, and indeed generally fills the entire space between it and the plug of hairs that blocks the corolla-tube.

Now, if the development of the flowers be carefully watched, a number of curious and interesting phenomena will be observed. Before the flower-bud opens the corolla has nearly reached its full size, and the flower lies in a slightly drooping position, or with its axis horizontal. The front of the corolla-tube is closed by the infolding of the corolla-lobes. The superior lobe lies outermost, the lateral lobes of the lower lip lie within this, and the strongly incurved inferior lobe lies innermost. The stamens are already full-grown. The tips of the filaments are sharply curved downwards, and the anthers, already beginning to dehisce and shed their pollen, are held within the concave infolding of the lowermost lobe of the under lip.

The flower opens by the successive bending back of the lobes of the corolla already mentioned. The deflexed filaments are not elastic, and seem to take little, and probably no, part in hastening the opening of the floral-box containing them. The anthers are now ripe, and the pollen-sacs are gradually everted so that most of the pollen falls, or is blown or is brushed away while the anthers stand in the axis of the corolla-tube. In the course of a day or two the filaments straighten themselves out, and finally lie along the upper internal surface of the corolla-tube, and are closely appressed to it, eventually projecting a little beyond the upper lip. The pollen meanwhile has all been shed, and the anthers are shrivelled and withered.

When the corolla has fully opened the secretion of nectar begins, but it is scanty at first. The style at this stage is little more than half-grown, and lies against the upper part of the corolla-tube, between the two pairs of filaments. When the corolla is fully expanded the style begins to elongate, and in two or three days, when the filaments have completed their straightening, it has grown as long as the stamens. When nearly full-grown its tips begin to curve forwards towards the axis of the flower, and ere long the style-branches open back in the axis of the flower and develop their small terminal stigmatic surfaces ready to receive any grains of pollen that may be brought in contact with them. Throughout this development of the style the secretion of nectar continues to be most abundant, and drops of it will gradually fall out of the corolla-tube if the branches are shaken. The secretion generally continues until the corolla begins to wither.

These are the facts disclosed by careful observation. We see at once that the pollination of the pistil of a flower by pollen from the anthers of the same flower is practically impossible, for the pollen is matured and shed long before the pistil is full-grown or ready for pollination. The movements by which the anthers, and after a few days' interval the style-branches, are

placed and kept for a considerable time in the axis of the corolla-tube are evidently designed to bring about pollination of the pistil by the pollen of some other flower. That other flower may be on the same tree or may be on another. Whether the pollen from another tree is prepotent over that of other flowers on the same tree I am unable to say, and only an elaborate inquiry could decide. It is, however, obvious that, owing to the prolonged period of flowering of single trees, there are abundant opportunities of pollination with the pollen of other flowers on the same tree.

Let us now consider what may be the agents that effect pollination. There is nothing to suggest that the wind blows the pollen from flower to flower or from tree to tree, for all the structural features that characterize wind-fertilised flowers are absent. Though the secretion of nectar is both abundant and long-continued, flying insects do not frequent the flowers; and indeed the store of nectar is so carefully protected by the natural plug of matted hairs obstructing the corolla-tube that insects could reach it only by biting through the base of the corolla-tube, and this I have never known to occur. There is no doubt that pollination is effected exclusively by small birds. These constantly visit the flowers, hang on the rigid leaf-stalks or flower-stalks, and insert their bills into the corolla-tube to suck the nectar. In sucking the sweet juice the tui may be seen grasping a flower in one foot and turning it round into a more convenient position. In passing from flower to flower the birds cannot avoid bringing pollen from young flowers to older ones, and so effecting pollination. That the arrangement answers its purpose is shown by the fairly abundant fruit which the puriri bears even in the neighbourhood of cities, where native birds are now scarce.

The mechanism for securing pollination is much more complete in the puriri than in *Rhabdothamnus solandri*, the store of nectar is much more copious, and is secreted for a longer time, while the provision for preventing insects from plundering it is most complete.

Altogether the arrangements herein described constitute one of the most interesting and remarkable adaptations of floral structure to the habits of honey-sucking birds that have so far been detected in our flora.

IV.—GEOLOGY.

Art. XLIV.—*The Fossils of the Waitemata and Papakura Series.*

By E. Clarke.

[*Read before the Auckland Institute, 29th February, 1904.*

Plate XXXII.

I. Introductory.

The typical Waitemata beds consist of alternating soft sandstones and friable clays, both almost entirely unfossiliferous. Interbedded with these are several beds of volcanic and slate grits, a full description of which may be seen in the papers by Messrs. Mulgan and Fox (Appendix 27, 28).

The Papakura series is characterized by the occurrence of beds of limestone, and has yielded fairly numerous fossils. It seems doubtful whether those who have written about the Papakara series are quite agreed as to what and where that series is. Mr. Cox speaks of a "Papakura limestone forming high cliffs at Papakura" (App. 11, p. 13). I have not seen these cliffs of limestone. By "Papakura series" Hochstetter (its originator) meant the succession of clays and limestones seen in "Cooper and Smith's limestone quarries on the Hunua Mountains" (App. 4, p. 42).

Although a considerable amount of valuable stratigraphical work has been done, much remains to be done on palæontological lines. The age of the beds has not been determined by palæontological evidence since Hochstetter's time; and since then not only have the Waitemata and Papakura series yielded additional fossils, but also the number of described New Zealand Tertiary invertebrates has been increased, and the relative ages of the Tertiary strata have been more accurately determined.

The following list contains, so far as could be ascertained, all the specifically determined invertebrates, excepting *Bryozoa* and *Foraminifera*, found in the Waitematas near to and south of Auckland, and in the Pakakura series.

Considerable difficulty is experienced in trying to identify the Orakei Bay fossils. Owing to their abnormal smallness it is difficult to compare them with specimens from elsewhere.

The localities mentioned may all be found in the county maps, except Slippery Creek, which is kept in this paper since other geologists have used it. Hay's Creek is the name

appearing on the county map. If a fossil is found also in the northern extension of the Waitematas the fact is mentioned.

The following abbreviations are used: C.T.M.—"Catalogue of Tertiary Mollusca and Echinodermata of New Zealand," by Professor Hutton (Geological Survey publication); 1873. Harris—"Catalogue of Tertiary Mollusca: Part i., Australasia," by G. F. Harris (British Museum Catalogues); 1897. M.M.—"Manual of the New Zealand Mollusca," by Professor Hutton (Geol. Surv. publication); 1880. M.M.V. —"Macleay Memorial Volume: Part ii., The Pliocene Mollusca of New Zealand," by Professor Hutton (publication of Linnæn Soc. of N.S.W.); 1893. P.L.S.—"Proceedings of Linnæan Society of N.S.W.: Vol. i., Series ii., Mollusca of the Pareora and Oamaru Systems," by Professor Hutton. Ten.W.—"Palæontology of New Zealand: Part iv., Corals and Bryozoa of the Neozoic Period in New Zealand," by the Rev. J. E. Tenison-Woods (Geol. Surv. publication); 1880. Zittel and Eastman—"Zittel's Text-book of Palæontology, translated by Dr. Eastman."

After each locality is placed the name of the person who found the fossil there. The number refers to the number of his work in the appendix. Papakura and Slippery Creek I take to be synonymous.

A good many fossils were found by myself in the beds exposed in Slippery Creek which belong to the Papakura series. The most characteristic bed is the Papakura limestone, and as the other fossiliferous beds have not yet been described they have not been specified in naming the localities. They are, however, at no great vertical distance above or below the limestone.

Any value which this paper possesses is due to the criticism and advice of Professor Thomas. Although in no way responsible for the conclusions arrived at, he has generously sacrificed time for which he had many and better uses in directing and encouraging my work.

II. Invertebrate Fauna of Waitemata and Papakura Series.

Sub-kingdom I. PROTOZOA.

For an account of the *Foraminifera* of Orakei Bay, see App. 5.

Sub-kingdom II. CŒLENTERATA.

Class Anthozoa.

Flabellum laticostatum, Ten.W., p. 14.

Agrees fairly well with a specimen in Auckland University College museum (from fan-coral beds at junction of Thomas

and Porter Rivers), but there are differences—in the angle enclosed by the base, which is less than in the South Island specimen; in the marginal thickening of the septa, which is more pronounced; and in the external markings, which are fainter and more regular, with no concentric ones.

Locality.—Slippery Creek, *E. C.*

Range.—Oamaru.

Flabellum papakurense, sp. nov. Figs. 1 and 2.

More or less conical, but in some specimens (fig. 1) the sharp-pointed somewhat recurved apex stands in the middle of an almost flat area, from whose periphery the calice-walls rise as a cylinder. Aperture nearly circular; diameters 19 mm. and 16–18 mm. Thick outer layer of theca easily separable from inner. Near base are 6 to 8 rootlets. Septa in 3 cycles apparently, but in some specimens (fig. 1) their arrangement is irregular. In this variety the septa are thin, with granulated surface, the granules being more or less arranged in lines; towards the centre the septa diverge from the radial direction, seeming to lie over on their sides and anastomosing to form a false columella. In the one more strictly conical form obtained (fig. 2) the septa are stouter and more regular. No granules were observed. The first variety seems to have been worn so as to show the septa at a lower level, and this no doubt accounts for some of the differences noticed. Pali are absent.

There does not seem to be any grave objection to placing these specimens under *Flabellum*, unless it be the absence of compression. The septa anastomose irregularly in *F. rubrum* found in New Zealand waters.

Locality.—Slippery Creek, *E. C.*

Class ECHINOIDEA.

Schizaster rotundatus, C.T.M., p. 43.

Locality.—Papakura, *Hochstetter*, 3, p. 43.

Range.—Lower Oamaru.

Sub-kingdom V. MOLLUSCOIDEA.

Class BRYOZOA.

See App. 7. Mr. Fox (28) also identified a number of *Bryozoa.*

Class BRACHIOPODA.

Rhynchonella nigricans, M.M., p. 178.

Localities.—Little Omaha, *Cox*, 13, p. 31; Rodney, *Zittel*, 4, p. 61; Waikopua, *Park*, 19, p. 152, and *E. C.*; Papakura, *Park*, 19, p. 153, and *E. C.*; Motutapu, *Park*, 22, p. 226, and *E. C.*; Papakura and Cheltenham, *Fox*, 28, p. 468.

Range.—Oamaru to Recent.

Terebratella dorsata, C.T.M., p. 36.

Localities.—Little Omaha, *Cox*, 13, p. 31; Rodney, *Hochstetter*, 4, p. 61; Waikopua, *Park*, 19, p. 152; Papakura, *Park*, 10, p. 153, *Fox*, 28, p. 468, and *E. C.*; Cheltenham, *Park*, 22, p. 226, and *Fox*, 28, p. 468; Motutapu, *Park*, 22, p. 226.

Range.—Lower Pareora.

Terebratella cruenta, C.T.M., p. 36.

Locality.—Papakura, *Fox*, 28, p. 468.

Range.—Wanganui to Recent.

Magellania (Waldheimia) gravida, C.T.M., p. 36.

Localities.—Papakura, *Hutton*, 10, p. 246, *Hochstetter*, 4, p. 56, *Park*, 19, p. 164, *Fox*, 28, p. 468; Cheltenham, *Fox*, 28, p. 468.

Range.—Oamaru.

Sub-kingdom VI. MOLLUSCA.

Class PELECYPODA.

Leda fastidiosa, Hutton, P.L.S., p. 230. Fig. 3.

Through the kindness of Professor Thomas I am enabled to describe two specimens in Auckland University College museum from the Orakei Bay beds.

Subtrigonal, sheil somewhat ventricose, anterior end slightly produced, rounded, posterior beaked and keeled, somewhat more produced than anterior, angular, acuminate. Shell regularly concentrically striated. Length—(*a*) 6·5 mm., (*b*) 2·5 mm.; height—(*a*) 4 mm., (*b*) 1·5 mm.

This seems to agree with *L. fastidiosa*, but I have not had access to any figures of the species.

Range.—Pareora and Wanganui.

Limopsis aurita, Harris, p. 346.

Locality.—Slippery Creek, *E. C.*

Range.—Oamaru and Pareora.

Glycimeris (Pectunculus) globosus, Harris, p. 343.

Agrees well with specimens in Auckland University College museum from Trelissic basin; also with the description, except that the measurements both of the Papakura and Trelissic specimens are just half those given by Harris and Hutton.

Locality.—Slippery Creek, *E. C.*

Range.—Oamaru (?) and Pareora.

Ostrea nelsoniana, Harris, p. 301.

Localities.—Little Omaha, *Cox*, 13, p. 31; Papakura, *Park*, 19, p. 164, and *Fox*, 28, p. 468.

Range.—Oamaru and Pareora.

Ostrea wullerstorfi, Harris, p. 301.

Localities.—Motutapu, *Park*, 22, p. 226; Papakura, *Fox*, 28, p. 468; Rodney, *Hutton*, P.L.S., p. 237.

Range.—Oamaru to Pareora.

Anodonta elliptica, Hochstetter MSS. (Hutton, 8, p. 246).

Locality.—Papakura.

Range.—

Pecten aucklandicus, Zittel, 4, p. 53.

I have never found undoubted specimens of this species. The specimens of small smooth pectens seemed referable to damaged shells of *P. fischeri* or *Amussium zittelli*.

Localities.—Orakei, *Hochstetter*, 4, p. 53; Maungaroa, *Park*, 19. p. 163.

Range.—Only found in Waitemata beds.

Pecten beethami, Harris, p. 319.

Localities.—Motutapu and Arapaoa, *Park*, 22, p. 226, and 19, p. 167.

Range.—Oamaru and Pareora.

Pecten burnetti, C.T.M., p. 32.

Localities.—Motutapu and Cheltenham, *Park*, 22, p. 226; Papakura and Cheltenham, *Fox*, 28, p. 468; Orakei, *E. C.*

One specimen (height, 8 mm.; length, 7 mm.) is almost perfect, and seems nearer to this species than to *P. polymorphoides*.

Range.—Oamaru and Pareora.

Pecten convexus (= *P. vellicatus*), C.T.M., p. 32; M.M., p. 171.

Localities.—Cheltenham, *Park*, 19, p. 154; Orakei, *Fox*, 28, p. 468.

Range.—Lower Pareora to Recent.

Pecten fischeri, C.T.M., p. 30.

In connection with the fact that "Dr. Zittel has expressed doubts as to the specific identity of the Orakei pectens (*i.e.*, *fischeri* and *zittelli*) with those from Papakura" (Hutton, 10, p. 249), I obtained specimens of both from Papakura, which seemed identical with those from Orakei Bay.

Localities.—Komiti, *Cox*, 13, p. 17; Orakei, *Cox*, 13, p. 25, and *E. C.*; Papakura, *Hochstetter*, 5, p. 53, and *E. C.*; Arapaoa, *Cox*, 13, p. 33; Maungaroa and Orakei, *Park*, 19, p. 63; George's Bay, *Park*, 24, p. 399; Papakura, Cheltenham, and Orakei, *Fox*, 28, p. 468.

Range.—Oamaru and Pareora.

Pecten polymorphoides, Harris, p. 316.

Localities.—Little Omaha, *Cox*, 13, p. 31; Maungaroa and Orakei, *Park*, 19, p. 163; Cheltenham, *Park*, 22, p. 226;

Judge's Bay, *Park*, 24, p. 398; Cheltenham and Orakei, *Fox*, 28, p. 468; Orakei(?) and Papakura, *E. C.*

Range.—Oamaru and Pareora.

Pseudamussium hochstetteri, Harris, p. 323.

Localities.—Papakura, *Park*, 19, p. 153; *Fox*, 28, p. 468, *E. C.*; Motutapu, *Park*, 22, p. 226.

Range.—Oamaru and Pareora.

Amussium zittelli, Harris, p. 324.

Localities. — Komiti, *Cox*, 13, p. 17; Orakei, *Cox*, 13, p. 25, and *E. C.*; Arapaoa, *Cox*, 13, p. 33; Papakura, *Hochstetter*, 4, p. 53, and *E. C.*; Maungaroa and Orakei, *Park*, 19, p. 163; Cheltenham and Orakei, *Fox*, 28, p. 468.

Range.—Oamaru to Pareora.

Amussium papakurense, sp. nov. Fig. 4.

Shell quite inequilateral, very thin, shows externally a fine radial striation, internally the ribs (apparently 8, though only 7 are seen in my best specimen) characteristic of the genus. The ears are small, and, so far as could be seen, smooth. An apparently identical form was collected by Mr. E. K. Mulgan on the Waiwera–Warkworth Road, a few hundred yards beyond the Puhoi Bridge. Height, 24 mm.; length, about 21 mm.

Localities.—Reid's quarry, on the Papakura–Wairoa South Road, and Symonds Stream, near Slippery Creek, *E. C.*

Lima bullata, Harris, p. 311.

Localities.—Papakura and Orakei, *E. C.*; Arapaoa, *Cox*, 13, p. 33.

Range.—Lower Oamaru to Recent.

Crassatellites amplus, Harris, p. 365.

Localities.—Rodney, *Hochstetter*, 4, p. 46; Motutapu, *Park*, 22, p. 226.

Range.—Pareora.

Cardita awamoensis, Harris, p. 360.

Probably Professor Hutton's *C. patagonica* (P.L.S., p. 229) is the same, in which case it must have precedence over Harris's *C. awamoensis*.

Localities.—Papakura, *E. C.*; Arapaoa, *Park*, 19, p. 167 (?) (*Venericardia intermedia*).

Range.—Oamaru to Wanganui.

Class SCAPHOPODA.

Dentalium subgiganteum, d'Orbigny, 1852 (new name for *D. giganteum*, Sowerby).

Localities.—Papakura, *E. C.*; Arapaoa, *Park*, 19, p. 167.

Range.—Oamaru to Pareora.

Class GASTROPODA.

Calyptræa calyptræformis, Harris, p. 252.

Localities.—Orakei and Papakura, *E. C.*

Range.—Upper Oamaru to Recent.

Natica ovata, Harris, p. 259.

In general outline and the shape of the umbilical opening the specimens differ slightly, but only slightly, from those in Auckland University College museum from the Miocene of Trelissic basin.

Locality.—Papakura, *E. C.*

Range.—Oamaru to Wanganui.

Turritella cavershamensis, Harris, p. 242.

Localities.—Papakura, *E. C.*; Arapaoa, *Cox*, 13, p. 33.

Range.—Oamaru and Pareora.

Vaginella aucklandica, sp. nov. Fig. 5.

The shell is much more slender than *V. depressa* (Zittel and Eastman, p. 489, fig. 1021). A groove running right round the shell is usually the line along which breakage takes place, and thus no specimen has been found with the mouth uninjured. The one figured, however, shows something of this important part. Length of shell, 14 mm.; greatest breadth, 2 mm.

Through the kindness of Professor Thomas I have seen a copy of Tate's figure of *V. eligmostoma* in Trans. Roy. Soc. S. Aust., vol. ix., pl. xx., which differs considerably from any specimen obtained from the Waitematas.

Locality.—Orakei Bay, *E. C.* A *Vaginella* has been reported by Hochstetter and many others from Orakei. Hochstetter also found one at Papakura.

Sub-kingdom VII. ARTHROPODA.

Class CRUSTACEA.

Pollicipes aucklandicus, Benham, Geol. Mag., March, 1903, p. 110.

Locality.—Motutapu Island.

Range.—This species is, so far, peculiar to Waitemata beds. Has hitherto been called a *Scalpellum*. Mr. Cheesman kindly called my attention to Professor Benham's paper, which I had missed.

III. SUMMARY.

Up to the present the palæontological evidence as to the age of the Papakura and Waitemata series is as follows:—

(*a.*) Of the twenty-four species found in the Papakura series, *three* are found elsewhere only in rocks of Oamaru

age, *one* in Pareora, *eleven* both in Oamaru and Pareora, *two* range from Oamaru to Wanganui, *three* from Oamaru to Recent, *one* from Wanganui to Recent, and *three* have not yet been reported from other districts.

(*b.*) Of the eighteen species reported from the Orakei Bay and other beds near Auckland, *one* is found only in Oamaru rocks, *two* are found only in Pareora, *eight* both in Oamaru and Pareora, *one* both in Pareora and Wanganui, *three* range from Oamaru to Recent, and *three* have not yet been reported from other districts.

(*c.*) Of the eleven species common to the Waitemata and Papakura series, *one* is found only in Oamaru rocks, and *one* only in Pareora, *six* belong to both Oamaru and Pareora, and *three* range from Oamaru to Recent.

Appendix—Literature.

1. 1860. Rupert-Jones, Quart. Journ. Geol. Soc., xvi.
2. 1863, Zittel, Quart. Journ. Geol. Soc., xix., Miscellaneous, p. 20.
3. 1865? Hochstetter, Reise der "Novara," Geology, i.; also "Geology of New Zealand," published in Auckland.
4. 1865? Zittel, Reise der "Novara," Geology, ii.
5. 1865? Karrer, Reise der "Novara," Geology, ii.
6. 1865? Stache, Reise der "Novara," Geology, ii.
7. 1865? Stoliczka, Reise der "Novara," Geology, ii.
8. 1867. Hutton, Reports of Geological Survey of New Zealand.
9. 1870. Duncan, Quart. Journ. Geol. Soc., xxvi., p. 316.
10. 1870. Hutton, Trans. N.Z. Inst., iii., p. 244.
11. 1874–6. Cox, Geol. Surv. Reports.
12. 1876–7. Cox, Geol. Surv. Reports.
13. 1879–80. Cox, Geol. Surv. Reports.
14. 1879–80. Hector, Geol. Surv. Reports, Progress Report.
15. 1881. Cox, Geol. Surv. Reports.
16. 1883–4. McKay, Geol. Surv. Reports.
17. 1883–4. Hector, Geol. Surv. Reports, Progress Report.
18. 1884. Hutton, Trans. N.Z. Inst., xvii., p. 307.
19. 1885. Park, Geol. Surv. Reports.
20. 1885. Hector, Geol. Surv. Reports, Progress Report.
21. 1885. Hutton, Quart. Journ. Geol. Soc., xli., p. 209.
22. 1886–7. Park, Geol. Surv. Reports.
23. 1887–8. McKay, Geol. Surv. Reports.
24. 1889. Park, Trans. N.Z. Inst., xxii., p. 391.
25. 1897. Park, "Geology and Veins of the Hauraki Goldfields," published by N.Z. Inst. of Mining Engineers.

26. 1899. Hutton, Trans. N.Z. Inst., xxxii., p. 171.
27. 1901. Mulgan, Trans. N.Z. Inst., xxxiv., p. 414.
28. 1901. Fox, Trans. N.Z. Inst., xxxiv., p. 452.

EXPLANATION OF PLATE XXXII.

Figs. 1 and 2. *Flabellum papakurense*, sp. nov.: *a*, side view; *b*, view of base: both natural size. 1*c*, calice from above; 2*c*, part of calice: both × 2.

Fig. 3. *Leda fastidiosa* (specimen *b*): *a*, natural size; *b*, magnified (drawn with camera lucida).

Fig. 4. *Amussium papakurense*, sp. nov.: Chiefly a cast, the internal ribs being preserved; part of the shell showing the external ribbing is adherent (natural size).

Fig. 5. *Vaginella aucklandica*, sp. nov.: *a*, natural size; *b* and *c*, views from opposite sides: both × 2.

ART. XLV.—*Notes on the East Coast Earthquake of 9th August, 1904.*

By GEORGE HOGBEN, M.A.

[*Read before the Wellington Philosophical Society, November, 1904.*]

THIS earthquake was felt nearly all over the colony, from Auckland to Queenstown. Its effects were most marked in the Hawke's Bay and Wellington Districts, especially on and near the coast from Porangahau to Castlepoint, where rock-falls occurred from cliffs, and fissures were formed in the surface-crust, indicating an intensity of IX. (or nearly so) on the Rossi-Forel scale. In the area affected and in its intensity it closely resembled the earthquake of the 17th February, 1863, which proceeded from the same region of disturbance.

Memoranda or notices of the shock were received from the following places, the Roman numbers denoting the degree of intensity (in some cases only approximately):—

IX.: Castlepoint, Motuotaraia, Porangahau.

VIII.–IX.: Napier, Hastings, Te Aute, Kopua, Dannevirke, Pahiatua, Wellington.

VIII.: Woodville, Masterton, Featherston, Carterton.

VII.–VIII.: Wairoa, Palmerston North.

VII.: Gisborne, Feilding.

VI.: Opunake, Aramoho, Marton, Nelson, Blenheim, Taupo.

V.–VI.: New Plymouth, Hawera, Kaikoura, Motueka Collingwood, Wakapuaka.

V.: Greymouth, Hokitika, Westport, Christchurch.

IV.–V.: Auckland, Rotorua, Ashburton, Timaru.

IV.: Dunedin, Queenstown.

The significance of this grouping will appear from the Rossi-Forel scale, which I make no apology for quoting at length, as I believe it has never yet appeared with the absolute equivalents in any New Zealand publication. The Arabic figures express the equivalents on the absolute scale—that is, the maximum acceleration of the earth's surface in millimeters per second per second, the acceleration due to gravity being about 9,600 mm./sec.[2]

	Rossi-Forel Scale of Intensity.	Absolute Scale. mm./sec.[2]
I.	Recorded by a single seismograph, or by some seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer ...	20
II.	Recorded by seismographs of different kinds; felt by a small number of persons at rest ...	40
III.	Felt by several persons at rest; strong enough for the duration or the direction to be appreciable	60
IV.	Felt by persons in motion; disturbance of movable objects, doors, windows, cracking of ceilings	80
V.	Felt generally by every one; disturbance of furniture and beds, ringing of some bells...	110
VI.	General awakening of those asleep; general ringing of bells, oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs; some startled persons leave their dwellings	150
VII.	Overthrow of movable objects, fall of plaster, ringing of church bells, general panic, without damage to buildings	300
VIII.	Falls of chimneys, cracks in the walls of buildings	500
IX.	Partial or total destruction of some buildings...	1200
X.	Great disasters, ruins, disturbance of strata, fissures in the earth's crust, rock-falls from mountains	?

The Milne horizontal pendulum seismograph at Wellington gave a good record, and nearly all the phases were also recorded on the Milne instrument at the Perth Observatory, West Australia, to the Director of which I am indebted for a copy of the seismogram.

The best time-observations in New Zealand were—

	Beginning of Shock. H. min.
Napier	10 21·35
Wellington	10 21·5
Nelson	10 22·3
Christchurch	10 22·5
Wanganui	10 21·9

These, by the method of circles or the method of equations, gave the position of the origin as 42° 23½′ S. lat., 178° 58′ E. long.—that is, the epicentral area was situated about a point 215 miles S.E. by S. from Napier, and 227 miles E.S.E. from Wellington. The depth of the origin is uncertain, but it was probably about 15 miles (24 kilometers), or a very little less.

The transit-velocity of the large waves (longitudinal waves) was 129·6 miles per minute, or 3·48 kilom. per second.

The transit-velocity of the preliminary tremors (rapid fine waves), as determined from the seismographic records, was about 478 miles per minute, or 12·8 kilom. per second. The speed of the transverse waves, similarly determined, was 2·2 kilom. per second.

The averages of the corresponding numbers for nineteen large earthquakes, as calculated by Professor Omori and Mr. Imamura, of the Hongo Observatory, Tokyo, are—

	Kilom. per Second.
Preliminary tremors, velocity (V_1, Imamura)	13·2
Large waves (V_5)	3·3
Transverse waves (V_8)	2·1

[*Earthquake Investigation Committee of Japan.*]

The theoretical value of V_5 for hard granite is 3·95 kilom. per second: the value 3·48 kilom. per second would agree with a hypothesis that these waves passed for two-fifths of their path through granite, and for the other three-fifths through some such rock as limestone.

The seismogram taken at Wellington shows a very slight tilting towards the west, probably evidence of slipping or accelerated folding of the underlying rocks.

The main earthquake was preceded by slight shocks in July and August, and was followed by after-shocks (twenty or more) until October.

The origins of these and other earthquakes, notably that of 1863 already mentioned, and that of the 9th March, 1890, seem to be situated in or near a strip or region of the earth's crust shown on the map as EE (Plate XLIX.), which is parallel

to the axis of folding of the older Pliocene rocks in Hawke's Bay, and to the general axis of New Zealand. They are also just on the outside of the sloping plateau which about 250 miles to the E.S.E. rises above the sea as the Chatham Islands. Between this line of origins and the south-east coast of the North Island is a trough in the ocean-bed with a depth of 1,000 to 2,000 fathoms (AA).

It is probable that the earthquake of the 9th August was due to sudden slipping along a fault-plane, or other similar movement that occurred in the process of the "repacking" of the deeper rocks, consequent upon the continuance of the folding which the geological evidence shows to have been going on for many ages.

The maximum displacement or amplitude of an earth-particle may be calculated from the other elements of the earthquake: the data in this case give 2–2·5 mm. as the maximum horizonal displacement; the vertical displacement would consequently be not greater than $\frac{1}{2}$ mm. or $\frac{1}{50}$ in.

The isoseismals, or lines of equal earthquake-intensity, marked on the map confirm in a general way the conclusions already established in regard to the region of disturbance.

[I am indebted for valuable observations and notes of the earthquake to the Secretary of the Post and Telegraph Department and his officers, especially to Mr. Keys of Napier, and to many private persons, the careful notes collected by Mr. R. P. Soundy, of Dannevirke North School, being of great interest.]

Art. XLVI.—*The Path of Earthquake-waves through the Earth.**

By George Hogben, M.A.

[*Read before the Wellington Philosophical Society, November, 1904.*]

Plate XXXIII.

As it has been stated that the apparently high speed of the preliminary tremors in large earthquakes is to be accounted

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* Since writing this paper I have received from the Earthquake Investigation Committee of Japan a copy of a paper on the same subject by Mr. Imamura, of the Hongo Observatory, Tokyo, in which the writer arrives at the same conclusion from calculations based on nineteen severe earthquakes recorded at all the chief seismological stations of the world. My paper was written ten months before the receipt of Mr. Imamura's

for by the probable fact that they pass from the origin along chords to the several places of observation, I have examined the records of several earthquakes as given by Milne seismographs at different stations situated all over the world, with the object of determining the question whether the waves in question are propagated along arcs or chords of the earth.

Taking the great Guatemala earthquake of the 19th April, 1902, as a fair specimen of the calculations, the evidence is, in my opinion, almost wholly in favour of the theory that the fine vibrations commonly called "preliminary tremors" do not travel along chords, as some have maintained, but along arcs at no great depth, the most probable speed being, in the case of this earthquake, 15·6 kilometers per second.

The table shows the distances (arcual and chordal) of the observing stations from the origin of disturbance, and the times of arrival of the preliminary tremors.

The diagram shows the same facts in a graphical form, the dots showing the points on the velocity-curve for the same places on the assumption of paths along arcs, the small crosses corresponding points on the assumption that the paths were chordal. The scale of the diagram is so chosen that the same unit represents 1,000 kilometers along the axis of y, or 100 seconds along the axis of t. Hence the velocity at a distance y from the origin $= 10\,dy/dt$ kilometers, which can be read directly from the diagram.

It does not seem possible to make any assumption of varying rigidity and elasticity of the internal rocks that would account for the varying velocity on the latter assumption; whereas the fact that on the former hypothesis Imamura's curve is almost a straight line shows that the velocity is nearly constant (dy/dt = constant = 1·56; therefore $v = 15{\cdot}6$ kilometers per second, as stated above).

Theoretically, the velocity should be constant while the waves are travelling through a homogeneous medium. Hence we may fairly conclude that the waves travel parallel to the surface at a uniform depth such that the elasticity and rigidity of the rocks allow of a high velocity, probably between fifteen and twenty miles below the surface.

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paper, and I think it due to myself, as well as a confirmation of his investigation, to publish in brief the results at which I had arrived. But his diagram represents the facts so much better than the diagram accompanying my paper that I have substituted for the latter a modification of his diagram, introducing a simplification which I venture to think gives a still clearer graphical representation of the facts. This modified diagram I have called "Imamura's curve."

GUATEMALA EARTHQUAKE OF 19TH APRIL, 1902.
Preliminary Tremors.

Milne H.P. Station.	Epicentral Distance along Arc (γ).	Epicentral Distance along Chord (γ^1).	Time of Arrival of Preliminary Tremors. (Greenwich Mean Civil Time.) (Time at Origin, 2h. 26m.) H. min.	Time taken in Transit (t).
	Kilometers.	Kilometers.		Secs.
Toronto	3,422	3,381	2 30·5	270
Victoria (British Columbia)	4,800	4,687	2 31·3	318
Bidston (Liverpool) ..	8,578	7,944	2 35·0	540
San Fernando (Spain) ..	8,600	7,961	2 34·8	528
Shide (Isle of Wight) ..	8,744	8,073	2 35·4	564
Kew (England)	8,822	8,133	2 36·2	612
Wellington (New Zealand)	11,189	9,804	2 38·0	720
Tokyo	12,278	10,462	2 38·8	768
Bombay	15,922	12,085	2 43·3	1,038
Perth (Western Australia)	16,667	12,298	2 43·8	1,068
Batavia	17,856	12,552	2 43·7	1,062

ART. XLVII.—*On some Glaciated Stones from Queenstown, Lake Wakatipu.*

By EVELYN G. HOGG, M.A.

[*Read before the Canterbury Philosophical Institute, 30th November,* 1904.]

THE glacial deposits of New Zealand present one feature in a marked degree which serves to differentiate them from the similar deposits of other regions—namely, the extensive accumulations of morainic material with the almost entire absence of boulder-clay or till. The beds of boulder-clay are widely distributed over the recently glaciated parts of western Europe and North America. They are met with in considerable thickness in the Dwyka conglomerate of South Africa of Permo-Carboniferous age, and the glacial beds of the same age in south and south-eastern Australia may be traced almost continuously from Hallett's Cove, west of Adelaide, to Bacchus Marsh, in Victoria, by the accumulations of boulder-clay nearly always rich in striated stones. Boulder-clays of Permo-Carboniferous age occur on the west, north-west, and south-east coasts of Tasmania. On the other hand, these glacial beds of Australia and Tasmania are strikingly deficient in terminal moraines such as those which constitute a marked characteristic of the New Zealand beds. The nearest parallel, perhaps, to the New Zealand glaciation is that of Switzerland and North Italy, but in this

region the occurrence of striated stones in the glacial deposits, as for instance in the neighbourhood of the Lake of Zurich, is by no means rare.

Soon after my arrival in New Zealand my attention was drawn to the apparent absence of striated stones from the ice-formations of the country. Such literature on the geology of New Zealand as came under my notice was destitute of any mention of striated stones, and an examination of the striated stones in the Christchurch Museum showed that none were of local origin. Under these circumstances the discovery by my wife and myself of striated stones at two localities near Queenstown, Lake Wakatipu, seems of sufficient interest to be placed on record.

To the east of Queenstown lies a hill, locally known as Queenstown Hill, which rises to a height of about 1,000 ft. above the level of the lake. It is separated from the south-east spurs of Ben Lomond by a narrow gorge running north, through which passes the road to Arrowtown. On the south side it slopes gradually down to the narrow arm through which the lake-waters issue towards the Kawarau Falls. The hill is composed of schists and clay slates dipping in a westerly direction. At the foot of the hill is a thick deposit of coarse river-gravel, well exposed near the Roman Catholic Church. The lower part of the hill is covered with small scrub; higher up it is well grassed, though as the top is reached the bed-rock shows itself in increasing amount. A zigzag path has been cut recently up the west and south-west faces of the hill, and in making this path a considerable quantity of loose rounded stones has been exposed either on the path or on both sides of it. On ascending the hill by this path with my wife in January last our attention was attracted by the occurrence of rounded stones at a point about 400 ft. above the level of the lake. A close examination showed us that they were not river or lake gravel, but genuine striated stones, presenting all the typical signs in general shape and markings. They were met with at intervals as high as about the 600 ft. level, but above that we did not find them. Two of the specimens from this locality have been placed by Captain Hutton in the Christchurch Museum.

The other place at which we found the striated stones is about a mile and a half from Queenstown on the new carriage-road which is being made westward along the margin of the lake. The road in places has been cut through the surface-soil, and here the striated stones lie exposed in the bed of the road at a height of not more than 50 ft. above the level of the lake. They are not such good specimens as those obtained from the hill-track, but of their mode of origin there can be no doubt.

Such, briefly, are the conditions under which the striated stones occur, lying loose on the ground only where the grass or vegetation has been removed to a depth of a foot or more. Careful search failed to find any exposure of a matrix of clay or other material of glacial origin in which the stones were imbedded. If a boulder-clay exists at either of the localities in which the stones have been met with it will probably only be found by removing the soil to some depth. The occurrence of striated stones thus lying loose in the surface-soil is somewhat similar to the case of the glacial beds of Coleraine, Victoria, where there are large areas in which almost every stone lying loose on the ground is striated, while the matrix of boulder-clay is found only slightly exposed in two localities at a considerable distance from the areas in question.

The striated stones were all coarse- or fine-grained sandstone, often indurated. There is nothing to show that they may not be of purely local origin. There was no trace of granite or other rock quite foreign to the district. The stones were of moderate size, the longest dimension of the largest one seen not being more than 10 in. Nothing of the nature of a smoothed or striated surface of the bed-rock was to be seen, nor anything which could with certainty be described as a *roche moutonnée*.

Apart from the discovery of the stones themselves, the feature of greatest interest is the height above the lake-level at which they occur on the hill-track; but before dealing with this point it is necessary to refer very briefly to the general question of glaciation in the Lake Wakatipu basin.

There seems little reason to doubt that through the midst of the region now occupied by the waters of Lake Wakatipu originally flowed a river of large dimensions, whose course was continued through the area now occupied by the terminal moraine at Kingston. At a subsequent stage a submergence of the land sufficient to admit the waters of the ocean took place, and during a prolonged period of time beds of shale, sandstone, and limestone were being deposited in what is now the lake-basin. These beds attained a thickness of 600 ft., and are found on both sides of the lake, and it is therefore highly probable that they extended continuously right across the lake-basin. As they rest unconformably on the eroded edges of the underlying schists, and at Twelve-mile Creek dip in towards the lake at an angle of 15°, it is clear that considerable denudation had already taken place over the area of the lake-basin before the formation of these later beds. The scooping-out of the trough in which the limestone and its associated beds rest has been attributed to ice-action, but no sufficient evidence is forthcoming to support this view. Later on there was a re-elevation of the land, and again the work of

excavation took place. The limestone was cut through, and then the subjacent rocks, until a well-defined valley once more existed. Then came the great Glacier age, and down this valley moved a glacier formed by the junction of glaciers from the Rees and Dart. This glacier continued the work of excavation started by the ancient river. It is, of course, difficult to apportion to the river and the glacier the amount of excavation due to each. By some geologists it is held that while glaciers have considerable powers of abrasion they have little or no powers of excavation. The present bottom of Lake Wakatipu is between 300 ft. and 400 ft. below the sea-level, and if the main work of excavation was done by the river it is of course necessary to postulate that the bed of the river was considerably more than 300 ft. higher than the deepest part of the present bottom of the lake, as a large amount of filling-in may have taken place since the ice-front retreated and Lake Wakatipu was formed.

The existence of the sounds on the west coast of New Zealand seems to point to a widespread submergence of this region, as there is little reason to doubt that these arms of the sea were originally valleys eroded first by water and then by ice-action. On the other hand, if the excavation has been for the most part performed by a glacier, it is extremely difficult to explain away the marked absence of the graving-tools by which such excavation was done. The rock *débris* by which the bed of the glacier had been worn deeper and deeper would itself present evidence of the grinding and eroding processes in which it had taken part, and rounded, smoothed, and striated stones and boulders should exist in an abundance somewhat proportional to the erosion which had been effected through them.

Leaving this debatable point, we know that the glacier must have filled the lake-basin to a height slightly greater than the present level of the water. The main glacier was, in the opinion of Captain Hutton, joined at Frankton by the confluent glaciers of the valleys of the Arrow and Shotover, and the united ice-mass moved south to Kingston, where an extensive terminal moraine marks the stopping-place of the ice-front. During a long period of time accumulations of ice-borne *débris* must have been dumped here, filling the valley and finally erecting across it the dam which now blocks up the south end of the lake. Against this dam, and along the valley-bottom near and for some distance north of Kingston, the retreating glacier must have continued to deposit its burden of fine and coarse material. With the retreat and melting of the ice began the formation of Lake Wakatipu. The waters accumulated, and, their overflow escaping by the lowest available point, the River Kawarau came into existence. The presence of terraces at various points along the

shores of the lake shows that the waters once stood about 100 ft. higher than their present level.

It is well known that the recreation-ground at Queenstown, lying to the south of the town, and projecting as a narrow tongue of land into the lake in a westerly direction, is a moraine: it is important to note that no traces of this moraine are to be seen on the flanks of the Queenstown Hill except near the lake-level.

Two hypotheses may be framed tentatively to account for the presence of the striated stones at the high elevation at which they occur on the hill-track. The glacier flowing down the lake would have from White Point to Queenstown an easterly direction, and at the latter place its northern fringe would have its path directly barred by the Queenstown Hill. If there had existed a moderate slope to the hill on its western face it is possible that the edge of the glacier was impelled up the slope and reached the elevation of 600 ft. above the lake-level at which the striated stones now exist, while the blocking of the edge of the glacier here might be held to explain the presence of the moraine at the recreation-ground.

There are instances on record of a glacier having moved uphill under the action of an enormous *vis a tergo*, but this force is operative to the greatest extent on the deeper-seated parts of a glacier, and to a much less extent on the surface portions and edges of the glacier. It is to be noticed that the morainic material exists now only at and just above the lake-level, and also that there is a large area lying just north of the recreation-ground—what may be called Queenstown Harbour—which appears to be free from the morainic *débris*, when we should have expected it to have accumulated here if there had been any serious blocking of the glacier at the foot of Queenstown Hill—and there are great difficulties in supposing the morainic material to have been there once to the same extent as on the recreation-ground, and to have been subsequently removed by a creek or river which has now ceased to flow from any cause, or has had its course diverted. The terrace formation at Queenstown and the bed of river gravel previously referred to point to the former existence of a river discharging into Lake Wakatipu at Queenstown after its formation as a lake.

The deep gorge running north and separating Queenstown Hill from the south-east spurs of Ben Lomond must have been originally eroded by water or by ice. There is no antecedent improbability in picturing the watershed of the river which flowed through this gorge as having been the collecting-ground for snow which furnished a small tributary glacier which joined the lake at Queenstown, and, depositing its accumulated burden of material on the site of the recreation-ground, has built up the

moraine now existing there. The discovery in this moraine of blocks of greenstone or sandstone which could only have come from the west side of Lake Wakatipu does not disprove the theory just put forward as to the origin of the Queenstown moraine, as at the point where the tributary glacier joined the main glacier there must have been considerable commingling of material. Postulating, therefore, a glacier as once descending the gorge west of Queenstown Hill, we see, from the amount of river gravel and shingle deposited in the terrace at Queenstown, and also from the shallow depth of Lake Wakatipu in Queenstown Harbour, that after the glacier had ceased to flow, a stream of considerable size must have flowed through the gorge and deepened it to its present level, and therefore that when the glacier existed it must have moved at an elevation considerably above that of the present gorge, and this height may have been sufficient to enable the glacier to deposit in their present position the striated stones occuring on the hill-track. What subsequent changes of level have caused the river which once flowed through the gorge to flow no longer I am unable to state, but there can be no doubt that a river did once flow through the gorge.

The striated stones found on the carriage-track west of Queenstown were in all probability deposited there by the Lake Wakatipu glacier: there is no such difficulty of level as exists in the case of the stones on Queenstown Hill to be met in this case.

ART. XLVIII.—*The Artesian-water Basins of the Heretaunga Plain, Hawke's Bay.*

By H. HILL, B.A., F.G.S.

[*Read before the Hawke's Bay Philosophical Institute, 19th September,* 1904.]

Plates XXXIV–XLI.

THE Town of Hastings is situated almost in the centre of what is locally known as the Heretaunga Plain. Napier is at the northern end of the plain, and Pakipaki, for our purpose, may be set down as situated at the south end. Few persons, had they known the plain as it was even forty years ago, would have thought so many thriving settlements would have sprung up in what was at that time an area just emerging from the condition of impassable swamp.

At the time of the arrival of the first European settlers in Hawke's Bay the fertile area that is now the pride of the district was an untrodden swamp. Only sixty years have gone by since then, and it must be evident even to those not given to careful observation that the changes mark a period of progress that

points to great future possibilities. It would supply an interesting picture if one could show the condition of the country generally when civilising man first entered on the scene. The plain between Farndon and Pakipaki was covered with raupo, flax, tea-tree, scrub, and bush, and was so ramified by overflow and swamp channels as to make it impassable to man or beast.

The lower country about Meeanee, and between it and Napier, was an area of fairly deep water, and long after Europeans had begun to settle in the district large 5-ton boats plied between Napier and Pakowhai by way of Awatoto. At that time Pakowhai was a peninsula surrounded by water on three sides. In those early days there were no roads, and the natives themselves dwelt along the sea-beach, some at the mouth of the Maraetotara Stream, near the Kidnappers, and others at Te Awapuni, the present site of the Washout, and others at Maraetaha, in the Inner Harbour, and others at the small island on the Tangoio Beach, about eight miles or so from Napier. The Ngaruroro River then ran along the plain from Roy's Hill, passing between Hastings and Pakipaki, thence by way of Havelock it swept round the low flats that skirt the shingle-deposits that form the Tukituki in the vicinity of Te Mata, the river eventually reaching Pakowhai. There it was joined by the Waitio and other creeks, forming a deltoid area that can even now be traced across the country in the direction of Meeanee and Te Awapuni, near the Washout. The Ngaruroro changed its course at the time of the great flood of 1867, a year before the establishment of Hastings as a town. The present bed of the river is along the bed of the old Waitio Stream. Since the alteration of its course, the river has on several occasions broken through the right bank in the vicinity of Roy's Hill, thereby threatening a return to its old course.

The Tutaekuri River has also played an important part in recent times in modifying the surface features of the plain. Formerly the river, which now enters the plain at Redcliffe, entered at the Moteo, and so formed the fan-like area between Fernhill and Crissoge. The wearing-away of the limestones at Puketapu altered the course of the Tutaekuri, but even now in time of heavy flood the river overflows at the Moteo, and sends great quantities of water and *débris* into the plain by way of Omahu. In the great flood of 1897 the overflow waters from this river joined with the overflow from the Ngaruroro near Crissoge and the old flour-mill in the vicinity of Papakura, and, running along the low-lying area at the foot of the Papakura Hills, spread over the plain and formed one immense sea-like area in the direction of Meeanee, Pakowhai, Clive, and Te Awapuni, or what has since become known as the Washout.

The Tukituki River at first glance does not appear to have played such an important part in plain-building as the rivers already dealt with. The Tukituki did not always run through the gorge-like country at the place where the river enters the plain near Te Mata, on the south side of the plain. The limestones in the hills behind Havelock tell a story of past change. They are sadly broken and fractured along their highest parts, and, as seen from Hastings or Napier, appear to sink underneath the Heretaunga Plain in the direction of Roy's Hill. But towards the south-east they present a scarp of 200 ft. or more in vertical height that forms the left bank of the Tukituki River as it flows through a comparatively deep gorge before it enters the plain. The scarp appears as if the limestones here had been broken off from the limestones on the right bank of the river by some upward pressure, thus giving them a high tilt or dip under the plain in the direction of Fernhill and Omahu. The great fracture in the limestones provided a way for the Tukituki to flow from large lake-like areas that at one time existed over the whole country about Patangata, Waipawa, and Waipukurau, following the period when the great waterway through the Ruataniwha to the Wairarapa was closed, and when the Ruataniwha itself became a large lake of great depth. The overflow from these waters entered the bay through what is now known as the Middle Road, between Havelock and Patangata, but this line was changed when the limestones were fractured along the line extending from lower Patangata to Te Mata, on the south side of the Heretaunga Plain.

Now, the changes that have taken place in connection with the three rivers named are of a comparatively recent date. By this is meant that in comparison with other changes of surface over the district the building-up of the Heretaunga Plain does not express a long period of time in comparison with other earth-changes. As viewed from our own immediate standpoint, the present plain presents certain characteristics, and we are aware of changes taking place in the surface-features of the country, as the direct result of material that the three rivers bring down on to the plain in times of flood, the Tukituki from the Ruahine Mountains, the Ngaruroro from the vicinity of Kuripapango, and the Tutaekuri from the Kaweka Mountains.

At the present time a large portion of the Heretaunga Plain, as already pointed out, has been drained and made fit for the abode of man. There yet remains, however, a fairly large area of unmade plain, which is now in process of formation, the portion known as the Whare-o-Maraenui Swamp area being dealt with by mechanical means. This portion of the plain contains over 1,700 acres, and it is the property of the Napier

Harbour Board. This special swamp-area supplies an excellent example as to the amount of material that the rivers bring down in times of flood. It has been explained that formerly 5-ton boats plied between Napier and Pakowhai, and the whole of the swamp-area consisted of little else than fairly deep water. As floods took place, heavy deposits of silt, &c., were left in various places, and at times the land was raised many feet in height. Thus the area now under notice has been raised so rapidly that a syndicate a few years ago undertook the heavy responsibility of reclaiming the swamp and raising 300 acres of it a foot above the flood-level of 1897 within five years, whilst the remaining acres were to be improved and made capable of cultivation. In other words, the land was to be so improved under ordinary conditions as to be capable of occupation. The work that has been carried out since the arrangement was made supplies matter of much interest and of public value, and gives a clue as to the time that it would likely take to build up a plain such as the Heretaunga Plain presents to-day, assuming that the physical conditions in this Island have undergone no material modification.

Even a cursory inspection of the Heretaunga Plain is sufficient to show an ordinary observer that the plain is bounded by hills which appear to be continuous with the sea-cliffs that bound the northern portion of Hawke's Bay in the direction of Petane and Wairoa, and that continue round the Inner Harbour to the Quarantine Island, the land just emerging above sea-level between the latter island and the Taradale Road, where a branch road running to Whareangi has dammed back the sea in recent years; but the brackish creeks that reach the base of the hills towards Halliwell's and the vineyards at Taradale bear testimony to the fact of sea-action in times past, and that in the same way the sea-waters had swept the foot of the Taradale and Redcliffe Hills, and thence by way of Papakura had swept the whole of the area of what is at present known as the Heretaunga Plain, even running far into the channels to the westward of Pakipaki and the north-west of Maraekakaho. At the time small bays were formed, and there existed the islands of Fernhill and Roy's Hill, just as there exist Scinde Island, the Watchman, and others in the Inner Harbour. If we follow the line of hills that reach the plain between Maraekakaho and Pakipaki, and thence to Pukahu, Havelock, and the Kidnappers, and imagine for the moment that the plain has disappeared, it will at once become apparent that what are now low-lying hills on the north and west of the Heretaunga Plain were at one time cliffs presenting a face to the ocean as bold and as rugged as the Kidnappers do to-day. But the cliffs and the hills themselves will even now help us to determine the question that we have to decide, as to the geological

history of the area known as Hawke's Bay and the Heretaunga Plain. The two have a similar history, and must be read together, although they are to-day so unlike. The present Heretaunga Plain was at one period a mere portion of Hawke's Bay. The whole of the area extending from Mahia Peninsula to Maraekakaho was once covered with land, and formed a portion of the East Coast district. Then came a period of subsidence along the east coast, and of elevation in the direction of the Ruahines and the Kawekas, and great changes took place in the surface-features of the country between the rising mountains in the west and the subsiding coast area.

In order to make these statements clear we must see what the rocks themselves tell of the story of the past; for it is largely by means of what is left that we can tell something of what once was. A visit to an old castle-ruin does not show us the stately scenes that once took place in the banqueting-hall; but a study of the social life of the period when the castle was built will enable us to dovetail some of the doings of the people so as to form a complete whole of what is to-day a mere ruin and desolation, and our own imaginings will do the rest. Geology speaks in the same way. Every rock and every stone tells a history, just as the lower hills at Havelock, at Redcliffe, near Taradale, and the cliffs at the Kidnappers, tell a story that cannot be misread by those who are anxious to discover truth as supplied in nature's storehouse. All the lower hills near Havelock are made up of shingle-deposits so recent that Mr. Leipst, the noted well-sinker of Hastings, brought up with his machine a few days ago from a depth of 200 ft. a part of the bone of a bird (probably a kaka) in a well that he is sinking at Te Mata. Similar shingle and pumice deposits appear at Redcliffe, near Taradale; and if we go along the beach from Mr. F. Gordon's station in the direction of the Kidnappers we shall find scores and scores of feet of shingle-beds, pumice-beds, and other beds, deposited as regularly as if they had been arranged by human hands. In Napier the merest remnants of the shingle-beds remain, but when found they tell the same kind of story as do the shingle-deposits at Havelock and the Kidnappers. And so of the islands in the Inner Harbour, the cliffs bounding the harbour, as at Maraetaha, Petane, and along the shore hills in the direction of Tangoia: all present similar characteristics, all show deposits of shingle and pumice, and all present to the bay a vertical face, as if they had been cut away by means of a sharp knife.

Try to imagine Hawke's Bay, or, rather, the Hawke's Bay extended district such as it was when the bay that is now covered with water was covered with land. The locality known as the Kidnappers continued north-north-east to Portland Island, and

the Mahia and the intervening area was covered with blue-clay sands and marls, or with limestones. It was at this period that great changes began towards the interior of the Island. The volcanic district was the centre of unusual disturbances, and the country between it and us was broken, and swept by floods of shingle and sand, alternating with showers of pumice, that spread over the country to the northward of parallel 39·40° S. At that time the watershed of the Taupo country was directed towards the north-east, and it was from the country in the vicinity of the present Mohaka River source that the heavy deposits of shingle and sand appear to have come. The shingle and pumice deposits extend from Pohui, at the base of Te Waka, on the Taupo Road, south-west along the Matapiro country into the Ruataniwha Plain, and thence generally southward, replacing the limestones that flanked and that also covered at one period what are now the Ruahine Mountains. Similar deposits fanned to the eastward, and spread as far as the Black Reef at the Kidnappers, the shingle and sand deposits between Pohui and Petane, along the present Napier–Taupo main road, being very largely developed. It was following the comparatively rapid deposition of shingle, sands, and pumice that the period of subsidence began which ended in the complete disappearance of the immense area extending from the Mahia Peninsula right away to the hills between the present Pakipaki and Maraekakaho, whilst the rifts or fractures that were made extended from Pakipaki to the Te Aute Lake, and from Maraekakaho on and on in an irregular line into the Ruataniwha district, where subsidence took place in a large measure corresponding and parallel with the line of elevation now known as the Ruahine and Kaweka Mountains. As remarked already, during the subsidence areas like Scinde Island, Fernhill, Roy's Hill, the Watchman, and a number of others of less importance became islands, separated from the mainland and washed by the incoming ocean.

The subsidence of such an extent of land as covered Hawke's Bay and what is now the Heretaunga Plain, in combination with the volcanic disturbances that continued in the centre of the Island, brought changes in the surface-features of the country that have resulted in what is now recognised as the river system of Hawke's Bay. The Tukituki River, even after the disappearance of the river which I may call the Great Wairarapa, of which it formed a tributary, continued to flow southward, but the throwing-out of heavy fanlike deposits from the rising Ruahines, by means of the mountain-streams flowing eastward, eventually dammed back the main river at the south end beyond Takapau, and thus formed the Ruataniwha into a large lake. The filling of this lake, and its eventual overflow at what are now

the Waipukurau and Waipawa Gorges, led subsequently to the formation of large and important lake-areas—in fact, a chain of lakes—between Waipukurau and the gorge north of Patangata, and the surplus waters from these lakes reached the sea, some in the direction of Te Aute, some through what is known as the Middle Road leading from Havelock to Patangata, and some through the hills in the direction of the Kidnappers.

But the fracturing of the Havelock limestones, and alterations in the level of the Te Aute Valley rift, caused the diversion of the waters into what is now the bed of the Tukituki, thus causing the disappearance of the chain of lakes that are easily traceable to-day.

The Ngaruroro and the Tutaekuri formed a single tributary of the Great Wairarapa, but following the period of subsidence they became separate rivers and entered the then Heretaunga Bay, the Ngaruroro to the westward of Maraekakaho, and the Tutaekuri at the Moteo, where it eventually filled up the fanlike area between Fernhill and the mill near Crissoge.

We have now to consider the growth of the plain that has been built up, not, it may be, phœnix-like on the remnants of a subsiding area, but yet at a rapid rate considering that only the rivers named have played any part in the work of rebuilding and reconstruction. To make the matter clearer, it should be stated here that what is ordinarily known as the Heretaunga Plain is, from a geological point of view, only a portion of it. The area of deposition, and not merely the area that we know has been raised above sea-level, is the subject of our inquiries. As one portion of an area is being raised above the level of the sea, another portion, and in fact other portions, are receiving deposits that are tending to raise them up to water-level, and it is necessary, therefore, in considering the growth of the Heretaunga Plain, to see how far that growth has affected the bay that at present extends beyond the limits of the Heretaunga Plain. In times of flood the waters that reach the plain not merely overflow and spread fanlike deposits made up of the materials brought down, but the waters passing slowly into the sea carry much of the fine sediment to be deposited at varying distances and depths from the mouth or mouths of a river.

Those who have ever watched the formation-work as carried on by navvies when a railway is in course of construction must have noticed the carriage of material in trucks to be thrown down an embankment when being formed as a part of the permanent-way. Many loads of material are slowly thrown down before the horizontal movement takes place, but the filling-up is certain, and, as the necessary level is reached, the material continues to be thrown down to widen and form a base that

is much wider than the level way under formation. This process in a large measure illustrates the growth of the Heretaunga Plain. The material that the rivers brought down spread out fanlike in different directions, and, as the area of deposition filled up, the river was extended seaward, and it may be that the direction of deposition was altered or modified. This is plainly seen in the case of the Rivers Ngaruroro, Tutaekuri, and Tukituki, which have frequently altered their course, so that the fanlike deposits have spread themselves in large measure over the whole of what was a sunken area that extends from the fractured limestones at the back of Havelock to the limestones between Crissoge and Roy's Hill—that is, from north-west to south-east.

It is the deposition of the material from the rivers that has produced the bedding from which the artesian-water supplies are now obtained, and the varying character of the material brought down will help to explain why the whole of the beds underneath the surface are made up of similar deposits. Recognising, then, that as the filling-up process went on the sea was thrown further back by the making of the land, there will be little difficulty in understanding how at the present time the plain of which the occupied part is known as the Heretaunga Plain is a good deal larger than that which is at present above the level of the sea.

For purpose of reference, let the place locally known as the Washout, near Waitangi, be taken as the starting-point, and let us suppose that a place out in the bay is selected, fourteen miles away, and eight miles to the north-west of the Kidnappers. This area is almost a counterpart of the Heretaunga Plain.

The depth of the sea fourteen miles from the Washout in the direction of Mahia Peninsula is 168 ft. At twelve miles the depth is 144 ft., at ten miles it is 108 ft., at eight miles it is 90 ft., at six miles 72 ft., at four miles 60 ft., at two miles 48 ft., and at one mile the depth is 24 ft. Suppose there was no water over this portion of the bay, the land would be as flat and the slope as gradual as the Heretaunga Plain itself between Roy's Hill and Waitangi. This plain was formed in its greater part under similar conditions to the Heretaunga Plain, and, geologically considered, is contemporaneous with it, and forms a portion of it. The shingle beach that is so characteristic of the coast between the Kidnappers and Petane forms no portion of the plain under notice. Its history is limited to the time when the Tukituki broke through the limestones at the gorge near Te Mata, and subsequent to the final separation of Scinde Island from the mainland in the direction of the Quarantine Station. The shingle along the beach is limited both in breadth and depth,

and began to be formed when the larger portion of the plain was above water, as the exposure of the beds at the Washout in the flood of 1897 clearly showed. If the shingle beach were taken away, just as we supposed the water for fourteen miles out in the bay to be taken away, there would be a valley-plain thirty miles in length and from eight to ten miles in breadth, so flat and so gradual in the slope of the bedding that it would be impossible for the most perfect eye to distinguish the inclination of the beds. The character of the beds as they slope gradually into the bay will be better understood by pointing out a few facts as to the present height of the Heretaunga Plain. Roy's Hill is situated on the right bank of the Ngaruroro River, and is the last hill on the right when proceeding along the plain to Maraekakaho. Between it and the latter place the Ngaruroro River on several occasions has broken through the right bank in time of flood, and an embankment has been constructed for protective purposes. At this place the height of the plain is 166·4 ft., and it may be set down as the highest portion of the plain. The distance from the Washout at Waitangi is about fourteen miles in a straight line. From Roy's Hill to Pakipaki the distance is about eight miles, and from the latter place to the Washout is about twelve miles. From Roy's Hill to Havelock the distance is about eleven miles, and from Omahu Bridge to Havelock the distance is 7·75 miles. Now, Pakipaki is 32·39 ft. above sea-level; West Hastings is 44 ft.; East Hastings at the junction of the Havelock and Karamu Roads is 39·9 ft., and at the Havelock Bridge over the old bed of the Ngaruroro the height is 34 ft. above sea-level. Omahu at the bridge is 73 ft., at the Pa 63 ft., and at the old mill near Crissoge the height is 48·2 ft. Papakura is 36 ft., Redcliffe near the bridge is 25·25 ft., and Pakowhai is 18·5 ft. At the junction of the Hastings-Havelock roads, near the Mangateretere Public School, the height is 15·5 ft., and at the Clive Bridge Hotel the height is 11·5 ft., whilst at the Waitangi Bridge near the Washout the height is 7·25 ft. Taradale, at the junction of the Napier and Meeanee roads, is 16·75 ft.; at Meeanee, near the hotel, the height is 5·5 ft.; and at Awatoto it is 7 ft.

These facts as to the height and general slope of the plain that is already above sea-level are supplied by Mr. J. Rochfort, C.E., and they will enable us to interpret something as to the quantity and character of the material that has filled up a whole arm of the original area of subsidence in a fairly regular sequence of beds that get deeper and deeper as they run seaward, and eventually die out in the bay at a distance that may be fairly set down at fourteen or fifteen miles from the beach that runs between the Washout and Awatoto. Underlying this immense accumulation of deposits is the old sea-bottom, made up of blue

clay and brecciated limestones that extend in all directions underneath the sea, the limestones, and the plain, and is really the basin in which all the artesian-bearing beds have been deposited. The most sudden slopes in the plain are between Roy's Hill and Pakipaki, where in a distance of eight miles there is a fall from 166·4 ft. to 32·39 ft., or nearly 17 ft. to the mile, and between Roy's Hill and Omahu Pa, where in a distance of six miles the slope is 103 ft., or 27·17 ft. to the mile. Between Roy's Hill and Hastings the slope averages about 16 ft. to the mile, so that the Hastings slope in reality represents the middle of an immense fanlike area with its pivot or centre at Roy's Hill and the fan spreading from Omahu Pa to Pakipaki with a gradual tilt towards the latter place. If we keep in view the general slope of the plain as shown here, it will be evident that the filling-in of the plain was rather by way of the old course of the Ngaruroro, and that the filling-in was greatly assisted by the Tutaekuri, which came down from the Moteo and joined the Ngaruroro in the vicinity of Omahu. The Tukituki rendered no help in the formation of the western part of the Heretaunga Plain, but its burden of shingle, deposited in a fan-formation from Te Mata, diverted the course of the Ngaruroro, turning it northward when in vicinity of the old mill at Havelock, and this was the general direction of the latter river until the year 1867, when it was diverted into its present bed. If we follow to their sources the three rivers that pass across portions of the Heretaunga Plain, it will be found that only the Tukituki had its origin of a chainlike lake formation from the time its waters reached the Ruataniwha. The Ngaruroro and the Tutaekuri rush from the mountains through a deep gut without the trace of a valley formation, and the high angle of slope will be seen by reference to a map showing the Ngaruroro from its rise at about 1,800 ft. above sea-level to the sea, a distance of sixty miles. The basin-area of each of the three rivers is as follows: Tukituki, 937 square miles; Ngaruroro, 836 square miles; and the Tutaekuri, 326 square miles: or a total of 2,099 square miles.

The latter rivers run mainly through a shingle and light sandy country, covered here and there with a yet lighter pumice sand. The deep gorge-like bed of each river shows how rapidly the rocks are wearing away, and this process is greatly assisted by the high angle of inclination of the upper part of each river, which enables even the heaviest timber to be carried in time of flood. Thus the Ngaruroro from its source at the back of the Kaweka Mountains as far as Omahu has a fall of 40 ft. per mile, but between Omahu and Pakowhai the fall is suddenly reduced to about 8 ft. per mile, and for the remainer of its course the

fall is less than 4 ft. to the mile. A similar remark applies in the case of the Tutaekuri River, but not in the case of the Tukituki. Now, the Ngaruroro and Tutaekuri Rivers bring down large quantities of fine material from the back country, where comparatively soft rocks abound, and we find that in times of heavy flood many hundreds of acres of temporarily submerged land are considerably raised, and therefore improved. But this improvement is at times a great loss to settlers who may be residing in the lower basin of these rivers. The slope or fall in the case of each river is much greater than it is with larger and more important rivers in Europe and America, for few of them have a fall of more than 24 in. to the mile, but the Ngaruroro and Tutaekuri, even when nearing their entrance to the sea, have a fall of nearly 4 ft., or 48 in., to the mile.

How, then, comes the trouble from overflow in times of an excessive rainfall? The answer is to be found in the difference of slope or inclination between the upper and lower course of each river. In the upper course the water rushes down at a great speed, owing to its high inclination, and the carrying-capacity equally with the denuding-capacity is very considerably increased. Thus it comes to pass that what is easily carried by the River Ngaruroro in that part of it where the inclination amounts to 40 ft. to the mile cannot be carried where the inclination diminishes to 6 ft. to the mile, and finally to 4 ft. The rate of flow is stayed, and the carrying-capacity is diminished, so that flooding and the deposition of silt must immediately follow. It is for this reason that there has been so much spreading of material as soon as the flood-waters have reached the present plain-area, and the filling-in of one area has only opened a way for an adjoining area to be similarly dealt with; and this will explain in a large measure why there is so much general likeness in the beds that go to form what is known as the artesian basin. It would be impossible to suppose that the beds forming the Heretaunga Plain should be identical. The surface material of the plain to-day varies in quality and variety of material for the reason that deposition has taken place at different times. Speaking generally, there is comparatively little alteration in the character of the underlying water-bearing beds between Napier and Pakowhai, but they vary considerably in the direction of Redcliffe and West Clive. In other words, the beds in the general direction of the dip show more points of agreement than do the beds in the direction of their troughing. And just as the wells vary somewhat in their bedding, so also do they vary in depth. But the changes, whether in the depth of the water-bearing beds, or in the varying characters of the material passed through in the process of sinking, are only what might have been

expected under the conditions of deposition, but more particularly in the case of wells along the line extending from Clive to Taradale, as these places are towards the points of the troughing of the underlying beds, between which points the tides flowed when the Heretaunga area was an arm of the sea.

Commencing, then, at Pakipaki, which is 32·39 ft. above sea-level, artesian water is found at depths varying from 65 ft. to 80 ft., or an average depth of 72 ft., according to the point selected. This depth gives 42 ft. below sea-level, or about 208 ft. below the highest point on the plain. The depth corresponds to a spot in the bay somewhat less than two miles from the beach at Te Awapuni. At the Pakipaki Pa, and near the railway-station, the water flows several feet above the surface, but this overflow disappears on approaching the entrance to the Te Aute Valley in the direction of what was once the Pakipaki Hotel. At Pukahu, and at the railway-crossing, Longlands Road, about midway between Pakipaki and Hastings, water is obtained at depths varying from 80 ft. to 110 ft., or from 55 ft. to 60 ft. below sea-level, with a flow rising from 4 ft. to 8 ft. above the surface. The depth in the wells in these places corresponds to a point in the ocean four miles from the beach at Te Awapuni. Hastings may be set down as being 40 ft. above sea-level, and artesian water is obtained at depths varying from 130 ft. to 160 ft., in what is known as the first water-bearing area. Other supplies have been struck in deeper sinkings at 280 ft., at 404 ft., and at 529 ft., but for the present the first water-bearing beds will suffice. The depth of the latter bed corresponds to the depth of the ocean nine miles from Te Awapuni Beach. Pakowhai is 18·47 ft. above the sea, and artesian water is reached at depths varying from 140 ft. to 170 ft., or, say, 137 ft. below sea-level, and 303 ft. below the highest point on the plain. This depth corresponds to the depth of the ocean between eleven and twelve miles out in the bay. Te Awapuni is 7 ft. above sea-level, and water is reached at depths varying from 170 ft. to 200 ft. between this place and Awatoto. This depth corresponds to the depth in the ocean about fifteen miles out in the bay. The Napier artesian water is found at depths varying from 156 ft. to 240 ft., according to the proximity of the wells to the hills. There are water-bearing beds at a greater depth than this, but the upper bed corresponds with the line of water-bed that is first reached at Pakipaki. The height of flow at Napier in the best wells reaches 30 ft. or more. As we proceed from Napier or from Te Awapuni in the direction of Taradale, from Pakowhai in the direction of Redcliffe, from West Clive in the direction of the Grange and the Big Bush, and from Hastings in

the direction of Omahu, the depth of the wells diminishes with great regularity. Thus, at Meeanee the wells are 160 ft. deep, at Roseneath (midway between Meeanee and Taradale) they are 100 ft., whilst they vary from 60 ft. to 90 ft. at the latter place. At the site of the old Farndon Hotel the artesian well is 135 ft. in depth, at West Clive water is reached at 130 ft., at East Clive 90 ft., and at the Grange and in the vicinity of the Big Bush at depths varying from 60 ft. to 85 ft. The variation in depth at the places named corresponds to what might have been expected from the troughing of the beds in the directions indicated already.

It will be noticed that the increase in the depth of the first water-bearing bed from Pakipaki to the sea corresponds in a striking manner to the slope of the plain between Roy's Hill and Te Awapuni, as also to the increase in the depth of the sea along the area of depression. But we are led to assume that the same saturated bed supplies the whole of the wells of the first series by reason of the fact that they all have the same height of flow above sea-level, if allowance is made for friction in the different wells, as they deepen between Pakipaki and the sea.

Perhaps the best illustration of troughing and of the same source of supply is to be found in Napier itself. It is not necessary to refer in any detail to the number of wells within the Borough of Napier, but so long ago as 1888 several 6 in. wells were put down in Monroe Street. At the first well in the street towards Clive Square, and 24 chains from the hills, a 6 in. well was put down, and water was struck at 156 ft. A second well was put down 14 chains further along the street in a south-east direction, and water was struck at 196 ft. The value of these wells from a scientific standpoint was enhanced by the fact that three years earlier a well had been put down at the junction of Hastings and Munroe Streets, which is just 19 chains further to the south-east, so that three wells in the same straight line gave the following depths: First well, 156 ft.; second well, 196 ft; third well, 240 ft.; whilst 33 chains separated the first and third wells. The same water-bearing beds clearly supplied the three wells, as the height of flow was similar, and the striking of water in the second well perceptibly influenced the flow in the first well, as it did also the flow of other wells in the immediate vicinity. It seems to me that the upper water-bearing area over the district is connected, but it is certain that there are also areas where water is available which appear to be isolated and very limited in extent. Thus, in the case of Havelock, the wells between Hastings and the bridge that crosses the old bed of the Ngaruroro in the direction of Havelock are clearly connected, but the wells that have been sunk in Havelock itself are of varying depths, and must either belong to a second water-

bearing area or to a separate supply-basin. Thus, a well put down for Mr. McHardy reached 403 ft., and the water rises more than 30 ft. above the surface. Canon St. Hill's well is 400 ft., and the rise above the surface is 35 ft.; and yet near by another well was tried to the depth of 482 ft. without finding water. The well near the Havelock Hotel is 325 ft. deep, whilst one put down in Cemetery Road for Mr. Beecroft is only 177 ft. These varying depths show how necessary it is to keep records of all facts connected with the sinking for artesian water, as they not only supply important data that is of value to the geologist, but they eventually lead to generalisations of the utmost moment to settlement.

In other papers dealing with the subject of artesian wells I have dealt in detail as to the probable source of supply of the waters, and of the effect of high tide and of rainfall on the increase and the height of flow, and it is not necessary to deal further here with these aspects of inquiry. My purpose has been mainly to show how the surface features of a country are ever undergoing change, and how these changes in a large measure are modified and even brought about by movements and changes that may be hundreds of miles away. It has been a long time since the Kidnappers, Portland Island, the Mahia Peninsula, and the north-western portion of the present bay were united, and formed, with the present Heretaunga Plain, an area covered with limestones and other rocks. The subsidence that took place at that time was balanced by great changes to the westward and towards the centre of the Island, and since then the altering of the watersheds has brought about the partial refilling of the subsided area, and has given this district the magnificent Heretaunga Plain, with an equally magnificent artesian-water supply, the value of which it would be difficult to estimate. Nature's work is by no means completed. The filling-up of the Whare-o-maraenui Swamp will be a great work, and those who have undertaken it deserve success, for they have already earned it. But when the Whare-o-maraenui Block has become the abode of industrious settlers, the rivers will continue to carry down their burdens of fertility in times of flood, and deposition must and will take place within areas that will vary just as the areas have varied ever since the filling-in began. Observations, the recording of facts, the recognition of common interests and common benefits, will bring into play that foresight which will tend to minimise the destructive effects of heavy floods, whilst the plain will continue to extend by the filling-up of the Inner Harbour, for this is the next great work that the rivers Ngaruroro and Tutaekuri will accomplish. I purposely leave the interesting work in connection with the filling-in of the Whare-o-maraenui for another occasion.

ART. XLIX.—*Taupo Plateau and Lake: a Retrospect and Prospect.*

By H. HILL, B.A., F.G.S.

[*Read before the Hawke's Bay Philosophical Society, 7th September*, 1903.]

Plates XLII. and XLIII.

VERY little is yet known as to the history of the Taupo Plateau. Situated in the heart of the North Island, at an elevation varying from 1,400 ft. to 3,400 ft., with a gradual slope to the Bay of Plenty, it presents an area of exceptional interest to the geologist. Hochstetter in 1859 saw a portion of it, and his journey from Tokaanu at the south end of Lake Taupo to Tapuharuru at the north end, and thence on to Rotorua, enabled him to understand some of the geological aspects of this interesting region. But he little realised the extent of the volcanic area, or imagined that the whole of it was in a large measure directly connected with the history of volcanic phenomena extending over a much longer period than is usually assumed. We are so apt to view the isolated volcanic areas of to-day in their limited extent that we overlook the fact of the present areas of activity being connected directly and continuously with the earth's history from the time when the earth was a mass of molten matter. It is certain that new areas of volcanic agency have begun within the human period, and that volcanic cones have built themselves as mounds of accumulation by the material that has been thrown or has flowed from the crateral opening that is made by the gyration of superheated steam or gas during and following great earth-movements. But, whilst this is readily conceded, it must be evident from the study of volcanic phenomena and the distribution of volcanic products that volcanoes have always existed from the time when the solidification of the earth's crust took place. Nor is there any reason why many of the volcanoes now known should not be directly connected with the earliest period of the earth's history. If we assume that earth-changes have taken place without those great cataclysms which the earlier geologists assumed as necessary—and the evidence of the rocks is fairly complete that such changes were gradual and continuous—then it may be asked, why should there not be volcanoes that have existed through the varying changes of deposition as illustrated by the stratified rocks? The science of geology teaches us that the forces of nature are constant in their operation, although the results from period to period may be dissimilar. The external forces that are ever in operation in their action upon the earth's

surface, though similar in kind, are not continuous in intensity. The pressure of the atmosphere, the force and direction of the winds, the moisture in the air, the heat of the earth's surface, the movements of the water of the ocean, are ever changing, though always acting and operating in degree: hence it may be said that the forces of nature, although similar in kind, have been unlike in their results, as the outcome of the varying differentiations that are ever in progress.

But to return: Along the East Coast district of the North Island the stratified rocks are represented by Tertiary and the Younger Secondary. With a single exception there are no traces of volcanic rocks: this exception is at Red Island, some miles to the south of Cape Kidnappers. Fifty miles inland from the coast there is the country that is generally known as the volcanic district. Ruapehu in the south and White Island in the Bay of Plenty are usually understood as representing its southern and northern limits; but these are by no means sufficient to determine the extent of the area that is the direct outcome of volcanic phenomena. The present centres of volcanic activity are embraced in a large measure within the limits of the places named, but it must be set down that the larger portion of the North Island is the direct product of volcanic agency. From the south-west corner of the Island where the extinct volcanic cone of Mount Egmont stands, right away to Tarawera, fifty miles north-west of Napier, a volcanic line may be traced. Right away to the north from Egmont there are volcanic rocks, and it would seem as if the great bight between Egmont and Kaipara Harbour represented an area of subsidence that corresponds to an area of elevation midway between Taupo and the great bight above mentioned. At present the centre of volcanic activity is represented by a line running from the crater-puia on Ruapehu in a north-easterly direction, and embracing the whole of the area affected by the Tarawera eruption of 1886. But this line of activity far from represents the area of volcanic energy such as the Taupo Plateau has experienced in past times. The attention that has been paid to the active phenomena as they appear to-day has led to the partial neglect of historical volcanic phenomena in relation to the Island as a whole. As viewed by the activities such as they appear to-day, the volcanic phenomena compared with the past are small and almost insignificant. When it is considered how extensive is the volcanic belt and how widely distributed are the lavas of rhyolite, one is led to inquire as to the magnificent grandeur of the volcanoes of the past, or, if not volcanoes, then of welling seas of lava that spread in sheets over the Taupo Plateau for many hundreds of square miles. At the present

time we see extending from Ruapehu volcanic cones of accumulation with intervening areas of depression, and extending for two hundred miles or more across the Island. Ruapehu, Ngauruhoe, Tongariro, Pihanga, Motutaiko, Tauhara, Maunga-ongaonga, Kakaramea, Mount Tarawera, and Edgecumbe are the product of the welling-up of lavas, or they are the outcome of explosions by means of which great quantities of loose material have been thrown out of volcanic orifices. Still, it is of importance to notice that, notwithstanding the wide distribution of lavas over the eastern and western parts of the Taupo Plateau, there remain but few traces of those older volcanoes that must have preceded Ruapehu and other adjacent volcanoes in the history of the Taupo country.

In January, 1902, I had the pleasure of coaching to Taupo from Napier in company with Mr. Cheeseman, F.L.S., of the Auckland Museum. Between Petane and Taupo barometric observations were taken for every mile of the journey. Within fifty miles of Napier the volcanic lavas appear for the first time on the roadside, at an elevation of 1,520 ft. above sea-level. They are in the hills two miles or more to the eastward of Tarawera. The Maitai slates are the prevailing rocks, but the country in many places is deeply covered with fine white pumice, in which are seen many specimens of trees burnt to a charcoal. The lavas seem to have flowed through the valley from the west, for they are not seen in the exposed rocks near the Tarawera Township, but they appear in the ridge over which the coach passes, a mile or so to the west. This ridge runs as an offshoot from the main line of hills, and ends in a single hill overlooking the Waipunga River, into which a hot spring flows from the hill. In several places the lavas appear on the roadside in the beautiful valley known as the Nunneries, and between the 56th and the 57th milestone from Napier the rhyolitic lavas are largely developed. From this place onward to the Rangitikei River they appear as the only massive rock-structures by the way. At Ohinehuka (61 m.), where there is a small native settlement, the country is covered with heavy bush, but wherever an exposure of rocks is seen they are rhyolite lavas of a greyish dull colour. At the 65th milestone the road crosses the Waipunga Stream (2,100 ft.), and the entire bed is seen to be made up of lavas, and presents the appearance of paving-stones throughout the whole bed of the stream. A mile or so lower down the stream the rocks change somewhat, where three streams meet and fall into a deep gulch-like area between enormous walls of black basalt-like rock, which appears to have come from the hills a mile or two south-east of the falls. Beyond Waipunga the country begins to open into extensive swamp-areas leading

on to the Taupo Plateau. From this swamp-area long, deep, and narrow valleys run between cliffs of pumice. These cliffs present steep faces, as if they had been shorn, and they extend for miles without any apparent alteration in their width. The bottom of each valley shows the lava-sheet surface similar to what is to be seen in the Waipunga Stream. In many places the lava is exposed on the surface of the road, where a kind of "scaling" takes place after a frost. At the 67th milestone the height of the plateau is 2,350 ft., and here again the rhyolites are exposed. At the 68th milestone an extensive area of swamp country is reached, and from the basin-like appearance, surrounded by sloping hills, it seems as if this area was the remnant of an old volcanic crater. The walls remain, and what may be termed the crater-lip provides an exit for what is at present a large swamp-lake, and the source of the Waipunga and possibly other streams. Between the 68th and 69th milestones the land begins to rise, and it continues to do so as far as the 73rd milestone, which is 2,320 ft. above sea-level. The ridge separates the volcanic-crater basin from the present Rangitikei River basin. The ridge is made up entirely of loose pumice material overlying rhyolite lavas that must be 150 ft. or more below the surface, as the lavas are seen to form the bed of the Rangitikei River just as they do of the Waipunga Stream. The former river crosses the Taupo Plateau seventy-five miles from Napier, and at a height of 2,170 ft. above the sea. From the river the road gradually rises in the direction of Taupo. Thus, at the 78th milestone the height is 2,270 ft.; at the 80th, 2,335 ft.; the 83rd, 2,380 ft. This is the highest point of the plateau on the coach-road, and from here onward there is a gradual fall towards the lake. Thus, at the 84th milestone the height is 2,370 ft.: the 85th, 2,300 ft.; the 87th, 2,029 ft.; the 88th, 1,850 ft.; the 91st, 1,720 ft.; the 94th, 1,400 ft.; the 95th, 1,370 ft. This height is not far from the site of the Terrace Hotel, which is about two miles and a half from the Taupo Post-office, and 160 ft. above the level of the lake. Cussen gives the height of Lake Taupo at 1,200 ft., Hochstetter at 1,250 ft., and Dieffenbach at 1,337 ft. Compared with the height of the lake, it is interesting to notice the height of the lavas on the Napier side of the Tarawera Township. These lavas are 320 ft. above the surface of the lake, fifty miles further inland, and they gradually rise in the direction of Taupo, as they are 2,170 ft. above sea-level at the Rangitikei, and much higher than this in the low-lying hills that cross the plain to the north-west and south-east, a few miles further in the direction of Taupo. Between the 73rd and 83rd milestones the slope is towards the Rangitikei River, the longer slope being from the south-west. The latter

(83rd) milestone marks the watershed between Taupo and the Rangitikei River; but it is important to observe that the high ridge runs in the direction of Ruapehu and Ngauruhoe, whilst a glance at these mountains from the high plateau between the two slopes shows that the original drainage-area was to the eastward of the present Lake Taupo. Thus it seems that at one period in the history of volcanic activity a line of volcanoes existed twenty miles or more to the eastward of the present line, just as they did to the westward, and that from these volcanoes or great fissures issued sheets of lava of vast extent, with which no modern outflow in this Island can be compared.

It will have been noticed that from the 83rd to the 96th milestone there is a sudden fall to the lake. The fall is very noticeable when proceeding by coach, as old margin-lines or basins are to be seen, showing by their gradual slope what were at one period in the history of the plateau sloping banks to a large lake, equal in extent to Taupo itself, but now a dry area of pumice mounds, covered here and there with tussock-grass, hardy *Dracophyllum*, and a few stray gentians and alpine plants.

But it is necessary to obtain a full idea of the general character of the country in order to understand the great changes that must have taken place to bring about the present conformation of the district. The valley of the Rangitikei is much more than a mere Post-Tertiary and Pliocene area, as the geological map of the Island has it. The high ridge running between the Taupo Lake and the Rangitikei Valley in a north-westerly direction separates farther in the direction of the Kaingaroa Plain the drainage of the Waikato River from that of the Rangitaiki; but this was not always so. The lava-beds that cover the plateau preceded the deposition of the pumice and attendant volcanic grits and stones, and we have the fact that the swamp-area in the vicinity of the 68th milestone is much lower than the general area of the surrounding hills, which are composed wholly of rhyolitic lavas. Before the distribution of the pumice in such abundance over the Taupo Plateau it seems as if large volcanoes extended more to the eastward and ran across the plain in a north-westerly direction, crossing the present line of volcanic intensity. For many miles ridges can be traced from the coach-road between the Rangitikei River and Opepe, running in the direction of Wai-o-tapu. Many of these present the appearance of chimneys, and convey the idea that they are the remnant of crateral walls of volcanoes that once played an important part in the history of the volcanic area.

It is certain that the time was when Lake Taupo did not exist, and there could have been no Waikato such as is known to-day. The drainage or watershed of the country was very

much modified by the material that was thrown from the volcanoes of Ruapehu and Ngauruhoe. The ridge to the east of these mountains is known as the Onetapu Plain and Rangipo Desert. It is made of materials thrown from the mountains, and it forms the watershed between the north and south parts of the Island. The drainage appears to have been towards the Rangitaiki Basin and thence through the Kaingaroa Plain into the great Whakatane Swamp. Subsequently it went through the Wai-o-tapu Valley, and thence into the Tarawera River. The Waikato of to-day is the product of the Taupo Lake; but when did the lake come into existence, and under what circumstances ?

The whole of the western side of the lake is surrounded by cliffs that rise 1,500 ft. or more in vertical height from the bottom of the lake. Along the eastern and northern sides pumice is the predominant material, and in some places pumice cliffs rise to a height of 200 ft. or more above the surface of the lake. It is evident that important physical surface-changes must have taken place to bring about the conditions such as at present are to be found. A map of the Taupo district shows the present drainage-area of the lake. From Ruapehu and Ngauruhoe proceed many streams, of which the Tongariro (Waikato ?) is one of the chief. It falls into Lake Taupo at the south-eastern corner. At the northern end of the lake the Waikato River begins. It is the only river that flows from the lake, and represents the difference between the total inflow and the amount of evaporation that takes place. But the history of the lake is the history of volcanic phenomena along the line of weakness, which is at present the line of greatest activity within the volcanic zone. Thus, Tokaanu at the southern end of the lake, the Terraces and the Spa at the northern end, then Wairakei, Roto-kawa, Orakei-korako, Wai-o-tapu, and the great Rotomahana–Tarawera rift, are included within a belt drawn north-east and south-west so as to include the eastern and western sides of Lake Taupo. Within this belt all the phenomena traceable to volcanic action are to be found. But this line of weakness is only a remnant of volcanic action. The volcanic work on a large measure has been done; and that work is to be estimated not by the cones that remain along the present line of weakness, but rather by the distribution of lavas over a very large part of the middle and northern portions of the Island. The volcanic cones of Egmont, Ruapehu, &c., are mostly cones of accumulation made up of material that has been thrown out by explosive force and by the welling-up of lavas. As they grew in height, and during their earlier periods of activity, probably much larger flows of lava took place from

Ruapehu and adjacent volcanoes; but the area of country to the east of these extensive volcanoes and covered with lava is very limited in extent. Southward of Ruapehu volcanic lavas disappear beyond the base-limits of the mountain, and if large flows ever took place they must have spread in a northerly direction.

But it has been pointed out that the country between Tarawera and Taupo is composed mostly of rhyolitic lavas, and similar lavas are found for many miles to the westward of the lake at heights varying from 1,500 ft. to 3,500 ft. It may be that these lavas flowed from Tongariro; but, if so, great differential surface-movements must have taken place to account for the varying heights of the lavas, which are extensive over the country. Again, there are volcanic cones on either side of the lake, just as there are traces of old craters, with crumbling walls, and all these were probably formed at an earlier date than Tongariro, Ngauruhoe, and Ruapehu. It was during the period of activity of these latter mountains that Taupo as an area of depression was formed.

But in order to interpret the changes that actually took place it is necessary to study the site of the Tarawera eruption, where to-day the greatest activity is found within the volcanic belt of weakness. What took place at Tarawera in 1886 took place at Taupo at a period that may be measured by hundreds of years. The Tarawera eruption was an explosive one, by which is meant that it was brought about by superheated steam being imprisoned as in a boiler, the tension being so increased that the overlying rocks were unable to sustain the increasing strain.

It would seem that the first or initial step in volcanic phenomena is of an explosive character. A shaft is formed from below for the imprisoned steam or gases, and, as the pressure increases when the steam is nearing the surface, the final effort is explosive, a cup-like or crateral hollow being formed. The material thrown out of the shaft soon forms a rim, which continues to increase in height as the base becomes wider, and if the volcano continues active the mound of accumulation becomes cone-like in appearance. All this has taken place many times over within the volcanic belt, and both Rotomahana and Mount Tarawera showed the explosive effect of superheated steam acting along a line of weakness in the earth's crust. The crateral hollows that were formed became centres of increased activity, as they were the lines of least resistance to the gases and superheated waters from below. But what Rotomahana was before the eruption in 1886, and what it has since become, show the character of volcanic changes that go on incessantly within the limits of the

volcanic belt. The existence of the inimitable terraces, and the activities that prevailed over a large extent of country in their vicinity, showed that the underlying forces were yet powerful and far from being played out.

Lake Rotomahana was a warm lake of varying temperature at the time of the eruption. It had an area of 180 acres, and was situated 1,080 ft. above sea-level, or 120 ft. below the level of Lake Taupo. Near its northern end was the celebrated Te Tarata, or White Terrace, and on the western side of the lake was the Pink Terrace. Rotomahana communicated with Lake Tarawera by means of the Kaiwaka Stream of warm water, which entered the lake near Te Ariki, a small native settlement. Rotomahana Lake appears to have been little more than a lid covering in an intensely warm area—in fact, a crater solfatara that slowly became filled with warm water. Round about the lake were hundreds of hot springs that showed the intensity of the pressures in the vicinity of the lake. Every steam-vent, constant or not, is evidence of pressure. Hochstetter's map of Rotomahana, published in 1859, after his visit to New Zealand, shows the location of most of the ngawhas, puias, fumaroles, and solfataras that surrounded Rotomahana. After the eruption, what was Lake Rotomahana became a huge crater-like area, 515 ft. in depth, at the bottom of which stood a small lake about 10 acres in area. Within the crater intense activity prevailed: "the whole of the space seemed to be occupied by a vast number of small craters ejecting mud, water, and steam, all in a furious state of eruption; whilst ever and anon an explosion that caused the surrounding hills to shake denoted a more than usually violent outburst, which was accompanied by a discharge of great rocks." But the whole of those eruptive centres are now hundreds of feet beneath a lake that has increased since the eruption to the depth of Lake Taupo. To the north-east and south-west of Rotomahana deep chasms were formed, and many changes took place in the surface-features of the country. Without taking any estimate of the quantities of material from the chasms and rifts, Mr. Percy Smith, the late Surveyor-General, estimated that 600,000,000 cubic yards of material was thrown out of Rotomahana alone, the crater extending over 2,000 acres with an average depth of 515 ft. The lowest point of ejection was Rotomahana, and the highest Tarawera.

Attendant upon the eruptions at Rotomahana and Tarawera, and the formation of numerous craters of explosion, were a number of earthquake-cracks in the vicinity of Waikorua and Pareheru. Two photographs of these were taken by the late J. C. Blythe, an old friend of my own, who was at Wairoa at

the time of the eruption, and went through the awful experiences from which he escaped only with his life. The photographs show a downthrow and a subsidence, the latter of more than 90 ft., the sides being vertical. Here the difference is seen between a force acting upwards and overcoming the downward pressure, and a force acting downwards and overcoming the upward pressure. The former is explosive at the surface, and the latter simply shears and shows a steep face or faces along the boundary-area that subsides. If the whole of the area affected by the Tarawera eruption is traced, two separate and distinct activities are seen to have taken place—one upward and the other downward. The great quantity of material thrown out from the numerous vents and shafts, exclusive of Roto-mahana, shows the existence of underground movement. The scoria, blue mud, ashes, and many varieties of volcanic rocks were distributed for miles over the district affected by the explosions; but the material did not come from great depths, and appears to have been acted on by superheated steam of so high intensity that dust, and scoria, and steam rose over the seat of explosion to a height of many thousands of feet.

But all the phenomena of the Tarawera eruption such as were found in the mountains, in the rifted valleys, and about the subsided areas, were no more than the display that took place daily at Te Tarata and Otukapuarangi, or the White and Pink Terraces, but on a much grander scale than was daily displayed at those places. The explosions along the great fissure with its centre at Rotomahana were most likely the direct result of stoppages in various parts of the volcanic area, but which were manifested along the line of greatest weakness—a weakness that perhaps had its origin in the frequent shakings that had taken place in the immediate vicinity of Rotomahana. Mr. Percy Smith, in his excellent *résumé* of the Tarawera eruption, points out that the fissure seemed to prefer the face of a hill to the bottom of the valley; but the reason is that the valley passes across the lava-flows, and not in the direction taken by them as they move over the land when flowing from a volcanic orifice.

The Wai-o-tapu Valley is at present separated from the line of fissure by deposits from two volcanic mountains known as Maunga-kakaramea and Maunga-ongaonga, both of which show many signs of recent activity. Thus the valley of the Wai-o-tapu, with its crateral lakes, its mud volcanoes, terraces, fumaroles, geysers, and boiling springs, is only separated from the great fissure at Tarawera-Rotomahana by a comparatively low ridge of volcanic *débris*, and the earthquake-cracks at Pareheru and Waikorua are at the apex of the two valleys. The Wai-o-tapu stream begins in the crateral lakes at the foot of Kakaramea

and flows south-by-west, meeting the Waikato River near the place where the latter river takes its great north-west bend, about nineteen or twenty miles below the place where the river leaves the Taupo Lake. The Wai-o-tapu Valley presents direct evidence of explosions and of great changes throughout its entire length. The rifts, the crateral hollows, the boiling caldrons surrounded by terrace formations, and the numerous signs of volcanic activity, present appearances that are very similar to what are seen in the vicinity of Rotomahana and the line of the great fissure. But for the ridge between the two volcanoes at the head of the Wai-o-tapu Valley the great fissure would extend from Tarawera Mountain right away into the Wai-o-tapu, which is a part of the drainage-basin of the Waikato River, and in the direct line of another great rift, to which reference will be made in the sequel.

Up to the present reference has been made as to the build of the Taupo Plateau, the probable direction of the Waikato River before Lake Taupo existed, and the causes that led to the eruption at Tarawera in 1886, during which Rotomahana Lake became a great crateral hollow and a line of fissure was made extending for twelve miles. In the light of the facts that have been made available as the outcome of the Tarawera eruption it may be possible to obtain a clue as to the origin and history of the Taupo Lake.

Lake Taupo: Historical.

The first European to visit Lake Taupo, as far as we have any knowledge, was the Rev. Mr. Chapman, a church missionary, who visited it three weeks before the arrival of Mr. Bidwell. In his "Rambles in New Zealand," published in 1841 by W. S. Orr and Co., Paternoster Row, Mr. Bidwell writes: "As I was the second European who had ever seen Lake Taupo, my visit having taken place three weeks after my predecessor (Mr. Chapman), it is very certain my account of it, imperfect as it will be, must be the only one that has ever reached Europe, and may therefore be considered valuable. Tawpo [Taupo] is one of the most superb lakes in the world, not from its size, although that is considerable, but from the extreme magnificence of the scenery surrounding it. Mr. Chapman considers it to be thirty-five miles long and twenty broad. I do not think it is thirty-five miles, but the width is not overestimated at twenty. It is situated in lat. 39° 35′ S., east long. 175° (about). . . . The form of the lake is a sort of irregular triangle, with the two most distant angles forming the north and south ends. The most peculiar feature about Taupo is the immense height of the surrounding cliffs; they are always perpendicular, although in

some instances rising in terraces one behind the other and varying from 500 ft. to 1,000 ft. high in several parts of the lake, particularly north-north-west and north-east sides. These rise perpendicularly from the water to such a height that I never saw their tops through the clouds for above five minutes together during the whole eight days I was on the lake. . . . There are but few places where a canoe can land, and at these the beaches are short and narrow: they are covered with black sand, and always indicate the entrance of a small stream of water. . . . At the north end of the lake is a very peculiar mountain (Tauhara), with an outline as regular as if it had been the work of art. . . . The cliffs around the greater part of the lake are of a dark-greenish colour, tinged sometimes with red, and are basaltic. . . . The River Waikato runs into Taupo at the south-south-east end, and makes its exit at the north. At the place where it enters it is a small sluggish river about 25 yd. wide and from 2 ft. to 4 ft. deep. . . . On one side of the river, about two miles distant, is situated the great *pa* of Taupo, and on the east side, at about one mile from the river, is a small *pa* called Coteropo [Ko te Rapa ?], where I was encamped. There are several other *pas* on the west side of the lake, and three in the east, but not large ones. It is, however, decidedly the most populous place I have seen or heard of in the Island. I should think the population in the *pas* on the lake could not be less than five thousand."

Mr. Bidwell visited Taupo in March and April, 1839. On the 30th December of the same year the Rev. H. Williams, a Church missionary from the Bay of Islands, reached Tokaanu by way of the Wanganui River. His account is very bright, and is contained in the *Church Missionary Society Record* of January, 1842. He says, "We continued our march till 4, when we arrived at a settlement on Lake Taupo—a magnificent sheet of water about thirty miles in length, with very fine bays."

This account of a first visit to Lake Taupo is in marked contrast with that of the Rev. James Buller, who visited Taupo early in the year 1840. The following account is taken from the "Annual Report of the Wesleyan-Methodist" for the year ending April, 1841: "Taupo is a magnificent lake, covering a surface of at least three hundred miles. It is evidently the effect of a violent volcanic eruption at some remote period. Its neighbourhood abounds with hot springs and boiling pools, and the stupendous mountain Tongariro is still in action, sending forth its smoky volumes. The country in this part is very mountainous. Adjacent to Tongariro is the snowy mountain Ruapaka or Paretataitonga [Ruapehu], whose crested summit, rising into the clouds, is discernible from the sea on either

coast. Shocks of earthquakes are frequently felt at Taupo; but the natives, little conscious of their cause, have been in the habit of regarding them as tokens of fruitful seasons. Tongariro they supposed to be the place on which Maui's hook fastened when he fished up the Island of New Zealand. They have a curious tradition of the origin of its sulphurous fires: they say that a man or some other being named Ngatoroirangi, with his two sisters, Taungaroa and Haungaroa, came from a great distance in the north to fix their abode in this neighbourhood; but Ngatoroirangi, in ascending Ruapaka, found his feet affected by the snow, whereupon his sisters lit some brimstone on Tongariro to warm them, and, having cured his feet, they departed; but the brimstone has continued to burn since that period. They also say that Taranaki, or Mount Egmont, was formerly situated by the side of Tongariro, but that they quarrelled about another mountain named Kopihanga lying between them: they fought, Tongariro conquered, and Taranaki fled to his present position."

Dieffenbach,[1] in May, 1841, was the first man with scientific training who visited Taupo, and he thus writes of it: "Lake Taupo is situated in a straight line between Cape Egmont and the East Cape, the direction of which is nearly north-east and south-west. From bearings of the compass of points of the coast astronomically ascertained, its lat. is 38° 45′ S., and its long. 176° E. In this north-east and south-west direction the country is impressed with the traces of volcanic action, which is indeed still going on, and had its principal point of activity in the crater of Tongariro, the base of which is about twelve miles distant from the lake. There are, besides, innumerable boiling springs, solfataras, and tufas in the same line, and its eastern-most boundary is the island of Puhia-i-wakari, or White Island, which must be regarded as the summit of a crater still active and but little elevated above the level of the sea. Besides these proofs of a powerful volcanic action, there is in that geographical line a chain of lakes, most of them intimately connected with the eruptive character of the country. Of these lakes Taupo is the largest: it has an irregular triangular shape; its greatest length is about thirty-six miles, its greatest breadth not less than twenty-five; its borders are in many places deeply indented. . . . . The northern and western shores of the lake are the most hilly, while the eastern shore is much more open. Here, to the north-east, a volcanic cone marks the place where the River Waikato issues from the lake. . . . The scenery on the western shore of the lake is magnificent—vigorous trees overhanging the black trachitic or basaltic escarpments of the shore. . . . Where this shore joins the delta of the Waikato there is a narrow belt of flat land, on which stands the

village of Te Rapa. Behind it the hills rise to about 1,000 ft. above the lake. In ascending, the ground is found to be of a high temperature. The surface is bare, or is scantily covered with mosses and lichens: it is formed of a red or white clay of a soft and alkaline nature, which the natives use instead of soap, and sometimes eat."

The only other writer whom it is necessary to quote is Hochstetter, who visited New Zealand in 1859. The account of his visit to Taupo and the volcanic district is of much interest, and will be found in his volume entitled "New Zealand," page 365 *et seq.* He says: "Lake Taupo is a real inland sea, twenty-five miles long from south-west to north-east, its greatest breadth about twenty miles, and of a depth as yet unfathomed. It lies 1,250 ft. above the level of the sea. . . . . The lake is everywhere surrounded with volcanic formations. Quartzous trachytic lavas in the most different modifications of structure and colours (crystalline and vitreous), together with huge masses of pumice stone, are the prevailing rocks. They form round about the lake a high table-land from 2,000 ft. to 2,200 ft. above the level of the sea, upon which numerous volcanic cones arise, built up of trachyte, pherolite, trachydolerite, or andesite, and partly also of basalt. The lake itself evidently owes its origin to a break in the plateau, and seems to be of extraordinary depth, especially in its western half."

Since the time of Hochstetter, although there have been more detailed accounts written of Taupo and district, little additional information has become available. Both Dieffenbach and Hochstetter fully appreciated the extent of the volcanic forces in the hundreds of cones that are to be found scattered over the district. Some of the cones have no craters, and would seem to have had their origin as huge blisters on the flowing lavas as they met with surface waters that caused an expansion of steam. These are seen to the west of Tongariro and Ruapehu, and pass for miles across the country. They are also found on the Taupo Plain, such as at Maunganamu.

The actual dimensions of Lake Taupo, as given by the Survey Department, are—length, 24 miles 70 chains; breadth, 16½ miles; the area being 242 square miles, or a little over 154,000 acres. The depth may be said to vary between 390 ft. and 570 ft. It contains the small island of Motutaiko, situated towards the south-east of the lake. The form of the lake bears a strong likeness to the African continent. At the south end the Waikato, or, more correctly, the Tongariro, River enters the lake and forms a delta extending from Tokaanu round the south-east side for some miles. Between Tokaanu and the waterfall known as Waihi, at the south-west corner

of the lake, hot springs, fumaroles, and geysers are numerous, and on the slope of the hills at the back of the native settlement near Waihi — the home of the once celebrated native chief Te Heuheu — there is a large area of country in the solfatara state, and immediately behind stands the old volcanic cone of Kakaramea, 4,350 ft. in height. So also at the northern end of the lake, in the line of direction where the Waikato flows from the lake, similar phenomena occur as at the south-west end. At the place known as the "Terraces," and running five miles or more on to the Taupo Plain, hot springs, boiling caldrons, and steaming areas are common. The hot springs are in abundance on the shore of the lake, so that a cold bath in the lake and a hot bath on the beach can be had at any time. The Spa on the right bank of the Waikato shows numerous spots of activity formed here and there in valleys and in broken ground, which appear as countless springs on the surface. On either side of the river as you proceed there are scores of places where traces of volcanic agency may be met with.

At Wairakei, on the left bank of the Waikato, and Roto-kawa on the right bank, are hundreds of interesting spots that will occupy the student of geology for many days. Every aspect of volcanic phenomena is to be found, except the flow of lava and the expulsion of dust. There are steam-holes, geysers, thudding of the ground as from a hammer, mud-craters, and hundreds of crater-like areas where intense activity prevails in the solfatara and sulphur areas, as the various acid gases force themselves through the growing crystals of sulphur that are formed by the chilling of the gases.

Similar traces of volcanic activity appear further down the river to Orakeikorako, a little below the junction of the Waiotapu with the Waikato. This portion of the Waikato River has to be studied along with the lake, for the history of their origin is the same. The bed of the Waikato from its exit from the lake as far as Orakeikorako is through a rift—not a valley of denudation—which is as plainly marked as the Tarawera rift. From the south of the lake and extending to the north-east and north-west for many miles the country is covered with a capping of pumice, sometimes fine, sometimes mixed with fine grit and dust, and sometimes containing huge blocks of pumice mixed with blocks of various heavy lavas.

The Island of Motutaiko rises about 320 ft. above the present level of the lake. It is made up of some curious ropy lavas, some of which look like the rounded stems of small trees, branched here and there, but broken off a foot or two from the trunk, and some not unlike pieces of prepared starch. Capping the whole of the higher portion of the island is a deposit of

pumice, in places more than 60 ft. in thickness. The walls of the island rise out of the water in perpendicular cliffs, and the pumice presents the same steep face as the more solid and massive parts of the island. It could hardly be supposed that the pumice was deposited over the more massive rock-structures after the island was separated from the mainland. In fact, rocks on the strand to the eastward of the island clearly belong to the same series as is on the island, so that we may suppose there has been a subsidence along the eastern side of the lake since the deposit of pumice took place that covers not only Motutaiko but so large a portion of the North Island. Along the beach further to the north-east of the island there are traces of submergence, for large timber trees can be seen in the water with their roots still fixed in the ground.

The depression forming the lake-basin occupied a larger surface-area at one period of its history. An old beach is clearly traceable round the lake 100 ft. above the present level, and in places there are traces of several other beaches, the highest being 300 ft. or more above the lake. The pumice-deposits appear as if they had been saturated with water at one period of their history, and in sinkings in the vicinity of Taupo Township waterworn gravel is found here and there.

The following letter, dated the 16th September, 1903, from the Rev. H. J. Fletcher, of Taupo, will be found interesting: "There are several wells in Taupo Township which were sunk several years ago. The formation passed through is exactly that which can be seen along the shores of the lake at Taupo. Waterworn gravel such as I got in sinking my well is rather scarce, but a considerable patch occurs in the roadside just above the Huku, and, strange to say, several large masses of waterworn gravel cemented by puia-deposit into a compact rock are to be seen a short distance below the bridge at Taupo. The earthquake you allude to took place in August, 1895. In regard to the long valleys you mention, I have long thought that they were caused by a sudden fall in the level of the lake, either by the wearing-away of some barrier in the course of the river, or by the subsidence of a large area in the lake or adjacent to it. I am inclined to the latter."

Mr. Fletcher put down a well to the depth of 65 ft. at a spot 145 ft. above the level of the lake, and about 50 ft. down he met with a thin band of waterworn shingle. It is not difficult to realise the large surface-area that must at one time have formed a part of what is known as Lake Taupo.

In 1886 Mr. Cussen, an able officer of the Survey Department, made a hydrographic survey of Taupo, and gave some interesting information and facts concerning it. His paper will be found in

vol. xx., art. xlii., of the Transactions, and is well worth perusal. He estimates that the inflow per second from all the rivers flowing into Taupo amounts to 16,483 gallons, and the outflow to 16,230 gallons. Accepting these estimates as generally correct, and taking the dimensions of the lake as already stated, the cubical contents of the lake amount to nearly 100,000,000,000 yards, or a hundred and sixty times more than the quantity that is estimated by Mr. Percy Smith to have been thrown from Rotomahana at the time of the eruption in 1886. The daily inflow to the lake at 16,500 gallons per second is 1,425,600,000 gallons. At this rate of inflow, and without making any allowance for evaporation, the lake such as it is to-day would require 307 years to fill, and at least 1,200 years to increase the depth 300 ft. more, as the surface of the lake would become so largely extended.

And what has to be said of the Waikato River? There certainly could have been no Waikato River whilst the lake was filling, for the river is made up of the surplusage of the lake. Mr. Percy Smith, writing in May, 1894, "on the present state of the country immediately round the site of the Tarawera eruption," says that "the crater of Rotomahana, which was formed in 1886, and at the bottom of which was a lake 25 acres in extent, had filled up with water from a level of 565 ft. to 985 ft., or 420 ft.; and that the lake had grown in dimension from 25 acres to 5,600 acres." He points out that Rotomahana had yet to rise 95 ft. before its waters would commence to overflow and clear a channel down to the level of Lake Tarawera and drain off a considerable portion of the present Lake Rotomahana. This lake, with its extended rifts to the north-east and south-west, is separated from Lake Tarawera by "loose incoherent ejecta," and is the counterpart of Lake Taupo, with its north-east rift along what is now the Waikato River bed, and with Pihanga as the highest point of explosion to the south-west. What has taken place in connection with Rotomahana during the past eighteen years enables us to look back to a time when Taupo and district underwent hydrothermal disturbances of much greater intensity than was experienced at Tarawera. It was then that the pumice was spread over the Taupo district, and the lava plateau that is now so extensively covered with volcanic *débris* was split in twain and subsidence took place. The raised mass of *débris* that covers the land along the north end of the lake from the Terrace Hotel to the Spa Sanatorium represents material that has filled up a part of the original crateral rift, which can be traced for many miles down the present Waikato River.

When the later volcanic disturbances began, the present

Lake Taupo was the centre of the disturbed area; but crateral rifts appeared along extensive lines of weakness, including Wairakei and Roto-kawa. For many years the rift that narrowed to the north-east was filled with thousands of steam-vents, that have played an active part in cementing the pumice or in decomposing it by means of the acid gases that issue from the fissures under high temperatures. As pointed out by Judd, the action of acid gases causes iron, lime, and alkaline materials to be converted into soluble compounds known as sulphates, chlorides, carbonates, and borates, which on removal by rain leave a white powdery substance like chalk in outward appearance, but composed of almost pure silica; and this action is everywhere going on within the volcanic zone. For hundreds of years the rift through which the Waikato flows from Lake Taupo was the scene of intense hydrothermal activity not unlike what is seen to-day along the line of rift extending from Tarawera to Pareheru. On either side of the main rift there are deep transverse valleys that are directly connected with the present Waikato Valley, and in which hydrothermal action is still very active. If we suppose that Lake Taupo was once much fuller than it is now, there will be no difficulty in understanding the position of its outflow from the lake. The river passes through soft pumiceous material until it reaches lava-sheets farther down. The surface rocks in the vicinity of Taupo are composed of pumice and hard volcanic grits cemented together by the action of heat, and the same kind of indurated pumice and grit stone go to make up the material over which the river rushes and forms the celebrated Huka Fall.

If we accept the explanation here stated as to the origin of Lake Taupo, of its once much larger extent, and of its eventual overflow into the extensive rift that was formed in a north-east direction in the line of the Wai-o-tapu and Rotomahana, it will ready be understood that Tarawera, Rotomahana, and the active geysers and fumaroles in the Wai-o-tapu Valley but represent portions of a great fracture or fault that has at times affected the surface of the whole of the North Island. The high cliffs bounding the western shores of Taupo are made up of lava-flows. Even towards the top of the vertical cliffs at Karangahape Point a band of red scoriaceous lava is clearly seen from the deck of a steamer, although the band is 800 ft. or more above the surface of the lake. Karangahape is 2,465 ft. above sea-level; Motuopa, to the south-east, on the opposite side of the lake, is 1,632 ft.; and Mangamotu, to the north of the Hinemaiai River, on the east side of the lake, is 2,060 ft.; and old crater-cups are numerous about the lake. Between them stands Motutaiko, with its cap-covered deposit of fine powdery

and small pebbly pumice showing trituration and wear. If a line be drawn in the direction of the outlet of the lake and the raised pumice terrace extending between Maunganamu and the Crow's Nest, there will be no difficulty in understanding how the deposit on the Island of Motutaiko took place. It seems to me that the evidence of pumice capping the island, the existence of the Horomatangi reef and the submerged forest, point to a subsidence along the eastern side of the lake at a time when the water stood at least 320 ft. above its present level. The dry watercourses that are met with by the hundred surrounding the lake on the eastern side, and gradually dipping towards the lake, imply a rapid scouring of the pumice by a kind of rocking motion; and it was perhaps at this time that the waters of an extended Taupo Lake found their way through the north-east portion of the Taupo rift, forming what is now the Waikato River. Many explosions must have taken place at this time, for the evidence appears to be complete that the whole line extending from Ruapehu to Tarawera, and thence to Edgecumbe and White Island, constitutes a continuous line which is at times affected in one place, and at times in another, in accordance with the capacity of the overlying and ever-changing deposits to bear the strains set up from beneath. The disappearance of the waters to their present level in the Taupo Lake exposed hundreds of hot springs, geysers, fumaroles, &c., that were pressed down beneath the waters of the lake. The filling of the Rotomahana crater with water, underneath which are hundreds of intensely active lines of steam-tubes, of necessity creates new possibilities. If the weight of water or the pressure of the overlying water is sufficiently great to overcome the steam-pressure from below, the pressure will either accumulate or it will find a line of weakness in the underlying rocks. Waimangu Geyser is the outcome of the filling-up of Rotomahana with many millions of tons of water. The same things took place in the rift that now does duty for the Waikato River. In many places are geysers and other objects of volcanic phenomena which broke out as the result of the Taupo eruption and the subsequent filling-up of the crater-basin with water. Hence the phenomena seen over the whole of the volcanic district, as illustrated by hot springs, fumaroles, solfataras, and mud-volcanoes, are the outcome of unstable conditions that are set up by the constant changing of pressures, known as stress and strain. They are attendants of volcanic action, and they have acted for many years along the great fault-line of which Taupo is the centre.

Thus we come to view Taupo as having a similar origin to the rift in Tarawera Mountain, the crater-basin of Rotomahana, the subsiding areas at Pareheru and Waihoru, and the crater-

valley of the Wai-o-tapu. Elevation and depression are complementary events in the history of volcanic phenomena, and one cannot exist without the other. Probably ever since the watershed from Ruapehu and Tongariro presented the same general slope as at present a river has flowed towards the north, but, as explained already, its direction appears to have been into the Bay of Plenty. The present Waikato River could only have flowed after the filling-up of Taupo; and if the greater Taupo is considered, not less than twelve hundred years would have been required to fill the lake. During that time there could have been no Waikato River. Nor does it appear as if the Waikato had flowed for a long period. The rift through which the river flows is made up in many places of loose pumice, and yet the sides are steep and denudation has done but little, there being as yet no valley formation as usually understood.

PUMICE.

The Taupo Lake and the rift appear to have supplied the pumice which has covered so much country in the North Island; but how long ago cannot be stated. A glance at the country suggests a period that is comparatively recent. The freshness of the pumice, the absence of denudation, the limitation of vegetation, all show that no other volcanic event has taken place since the pumice was deposited. Maunganamu is composed of a fine trachyte almost similar in appearance to pumice, and resembles it in many respects. A similar deposit is met with along the northern portion of the lake. The great depression in which Taupo is situated might easily lead us to understand that extensive areas have been covered to a great depth with the *débris* that was thrown out, and so hidden volcanic orifices. Travellers have wondered at the extensive distribution of pumice over the Island, and every visitor to the volcanic district is struck with the everlasting sterility of the country where the pumice is found. The Napier hills a few feet below the surface are covered with it to the depth of several feet, and it is found, sometimes below a capping of black light soil, and sometimes as a surface deposit, over all the stratified-rock country to the westward as far as Tarawera. Further west the pumice-deposit increases, and the whole country is covered to the depth of many feet, the varieties being numerous. Beyond the Rangitaiki River the pumice is mixed with volcanic grits and angular and partly rounded stones such as are found on the strand at Taupo. As you descend towards the lake from Opepe every exposure by the roadside shows an increasing quantity of stones and rock-masses, and the latter increase in size, some being tons in weight. The distribution of the pumice, however, is not limited to the east-

ward of the lake: it is everywhere. Northward, westward, and southward similar deposits occur, but the quantity is much less to the southward, and volcanic grits and stones are absent. It is evident that the pumice-deposit is the most recent up to the time of the Tarawera eruption, as it is continuous over such a large extent of country, and shows that the distribution must have been from the same general centre. It would be difficult, if not impossible, to give even an estimate of the quantity of pumice that is distributed over the volcanic belt of this Island; but it seems certain that the ejection took place, as in the case of Rotomahana and Tarawera, suddenly, and as an attendant of hydrothermal activity. Volcanic outbursts do not send out the same kind of products, and it is doubtful whether any of the volcanoes to the south of Roto-aira have ever ejected pumice in quantity. Had the pumice been ejected from Ruapehu, Ngauruhoe, or Tongariro, much larger quantities might have been expected to the south and east of these mountains. Their growth and that of Mount Egmont is similar. Pumice is distributed by explosive means, lava by flows; the former is ejected, the latter wells and spreads as a plastic mass. In these mountains the traces of lava-flows are common, but not so in the case of pumice. A scoriaceous kind of pumice and clinker is spread lightly over the Rangipo Desert, but nowhere in the direction of the mountains; hence the probability is that the great rift extending from Pihanga through the present Lake Taupo and down the Waikato in the direction of Wai-o-tapu was brought about by explosions that spread pumice and varieties of lavas over such a large extent of country, just as the Rotomahana explosion spread blue mud, scoria, and varieties of shattered lavas.

What Rotomahana is becoming by the inflow of water, Taupo became perhaps hundreds of years ago. Volcanic action and volcanic phenomena are yet active in the North Island, and there is evidence of continuous activity from the Secondary period. Nor is there any reason to suppose that the volcanic district will not again be subject to lava-flows and explosions due to hydrothermal causes: both may be expected, and in the coming years science may be able to determine even the times of their coming.

ART. L.—*The Formation of the Canterbury Plains.*

By Captain F. W. HUTTON, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 2nd November,* 1904.]

THE Canterbury Plains are formed by beds of gravel, sand, and clay of varying thicknesses, covered in places by a layer of silt, or loam, which is used for brickmaking. North of Banks Peninsula the plains commence at the sea-level, but to the south they show on the sea-shore a range of low cliffs averaging some 25 ft. in height; so that about a mile more has been washed away on the south than on the north side of the peninsula. Inland they gradually ascend until at the base of the mountains which bound them they have attained to from 1,000 ft. to 1,500 ft. above the sea-level.

Near the mountains a few rocky islands, as we might call them, rise through the gravels to the surface. Of these View Hill and Burnt Hill have a volcanic origin; the hill at the lower gorge of the Waimakariri is formed of sandstones and slates of Older Mesozoic age; while Curiosity Shop, in the Rakaia, consists of Oligocene limestones and calcareous sandstones.

The thickness of the gravel-beds is not known. At Christchurch wells have been put down to a depth of more than 400 ft., and at that depth have come across deposits of wood, which must be either driftwood or the remains of an old forest lying where it grew.

The origin of the stones forming the gravels is obvious. Most of them are pieces of sandstone, sometimes with quartz veins running through them—a rock which is abundant in the mountains from which the rivers flow; while in the southern portions of the plains we also find chalcedony and volcanic rocks similar to those found from the Gawler Downs and Mount Somers to the Malvern Hills. Evidently the stones forming the gravel-beds have been brought down by the rivers; and this is confirmed by their subangular, or partly rounded, forms. If the gravels have been brought to their present positions by the rivers, so also have the sands, for they are only small fragments knocked off the sandstones; and we may say the same of the clays. Both the sands and the clays are mechanical deposits which have been sorted and arranged by moving water.

There are, however, certain irregularities in distribution which require careful examination—I mean the hills composed of gravel which rise above the general surface of the plains, such as the Moeraki Downs, Racecourse and Little Racecourse Hills, and Woolshed Hill. Of these, Woolshed and Little Racecourse Hills are partly morainic in origin, and contain large

boulders such as are not found in the ordinary gravels. But the shapes of the hills are not those of ordinary moraines left by glaciers: they are more of the nature of eskers — that is, low ridges composed of water-worn materials roughly stratified in places.

The Moeraki Downs show no trace of morainic origin. They are ordinary sand and gravel beds, standing out above the plains to a height of about 100 ft. How could they have been deposited? Certainly not under the present conditions. The rivers, when the gravels of the Moeraki Downs were deposited, must have run at a much higher level than they do now.

On the flanks of the Malvern Hills there are also patches of gravels resembling those of the Canterbury Plains. I have examined them in the neighbourhood of Sheffield, and estimated that they go to a height of 50 ft. to 70 ft. above the plains.* Again, at Fighting Hill, on the south-western side of the Malvern Hills, there is a bed of gravel, 1,700 ft. above the sea, which is not morainic in origin. It resembles a bar across the entrance to a sound or river, and it is impossible to imagine that it could have been built up by the Rakaia.

I have not examined the hills near the gorge of the Ashley on the northern boundary of the plains, and so I cannot say if any high-level patches of gravel are found there; but in the railway-cuttings north of the Waipara gravel-beds are found at a considerable height above the level of the plains.†

On Banks Peninsula there are no gravel-patches similar to those of the Canterbury Plains—nothing but fragments of local volcanic rocks covered by the silt-deposit which I have already mentioned.

Before trying to explain the origin of these high-level gravels it is necessary to consider two remarkable topographical features in the plains—I mean the lower gorges of the Waimakariri and Waipara Rivers. The first of these I brought to the notice of this Institute in a paper read on the 15th November, 1883; but it is so long ago that perhaps I may be allowed to draw your attention to it once more.

The Waimakariri, after debouching on the plains, is joined by the Kowai, coming from the south-west, and the two united rivers make straight for Gorge Hill and cut it in two, thus forming the lower gorge of the Waimakariri, which is crossed by the railway between Sheffield and Oxford. The hill is composed of sandstones, and rises about 270 ft. above the plains.‡ Above the

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* "Geological Reports," 1873–74, p. 56.
† Trans. N.Z. Inst., vol. xx., p. 263.
‡ Trans. N.Z. Inst., vol. xvi., p. 449.

gorge the river-bed is very wide and beautifully terraced, and the same occurs below the gorge; while in the gorge itself the river is confined within a narrow channel.

Now, how can we explain this? Evidently the river must at one time have run at a higher level than the top of the gorge. At that time nearly the whole of Gorge Hill would have been buried by sand and gravel beds, through which the river cut its way down. We can hardly doubt but that the high-level gravel-patches near Springfield are also part of these same gravel-beds, for they go up to about the same height. But how have the intermediate portions been removed? They could not have been removed by the river itself, because to do so the river must have left the gorge and cut a new channel at a lower level round the hill. If it had done this it could not possibly have regained its old level in the gorge, for that would be on a higher level. But the gravel-beds have evidently been removed by water—they could not have been blown away by the wind—and if they were not removed by the river the sea is the only agent left.

Now, take the lower gorge of the Waipara close to where it runs into the sea. This gorge has been cut through a spur from the neighbouring hills, which the river pierces instead of going round, as it certainly would have done if the river-bed had been marked out under the existing conditions. Here also, as in the case of the Waimakariri, we must assume that the river at some former time ran at a higher level than the spur through which it cuts, and that the greater part of the gravel-beds over which it then ran have been subsequently removed by the sea.

If we go outside the Canterbury Plains to look for collateral evidence we find it at Amuri Bluff, where a raised beach has been described by Mr. A. McKay, at a height of 500 ft. above the sea, containing marine shells of still living species. Again, at the mouth of the River Conway gravel terraces go to 300 ft. above the sea, but no shells have been found in them. And lastly, at Motunau marine shells of recent species are found in abundance at 150 ft. above the sea.

I cannot, therefore, agree with Sir Julius von Haast, in his report "On the Formation of the Canterbury Plains" (Christchurch, 1864), that these plains are entirely due to river-action. But I must believe that, although the materials of which they are formed were brought down from the mountains by the rivers and accumulated under river conditions, during a long period of subsidence the contour of the surface has been much modified by the subsequent action of the sea, which swept away a considerable portion of the upper beds when the land was probably 1,000 ft. lower than at present.*

* See, however, Haast in the Trans. N.Z. Inst., vol. vi., p. 421.

Two principal objections may be made to this hypothesis: the first is the absence of marine shells on the plains; the second is the absence of high-level gravels on the slopes of Banks Peninsula. Both, you will notice, are founded on negative evidence, which has less weight in geology than in any other department of science, on account of the imperfection of the record. The first objection I will postpone until later. The absence of marine beaches, or gravel-patches, on Banks Peninsula may be due either to the effects of subsequent atmospheric denudation, which has washed them away; or, which is more likely, the gravel-beds never reached high levels on Banks Peninsula, on account of its distance from the mountains.

A third objection is the shape of the stones which form the plains, which are not flattened as they should be if they had been exposed to long-continued wave-action on a sea-beach. But this objection would not apply to all the stones of the gravel-beds, only to an upper layer; and it is quite possible that the submergence did not last sufficiently long for the stones to assume the shape characteristic of a sea-beach.

We now come to the silt or loess which lies above the gravels. It is found in places all over the plains, and inland to Gorge Hill or beyond it. It is also found all round Banks Peninsula, where it is quite as well developed on the seaward as on the landward side. Here it occurs chiefly on the tops of the ridges, having been largely removed from the valleys by denudation. It is well seen in Lyttelton Harbour and along the Governor's Bay Road, as well as all along the foot of the hills from the Dyer's Pass Road to Sumner. On the coast between Lyttelton and Akaroa it also forms thick deposits, a section of some of which I gave in my paper in the "Transactions of the New Zealand Institute," vol. xv., p. 413. Sir Julius von Haast, who examined Banks Peninsula with considerable care, states that it goes up to a height of about 800 ft. above the sea; and, judging from what can be seen when going along the roads to Akaroa, I think that he is right. Near Amberley it is sometimes covered by fine river-gravels brought down by the River Ashley.

At Timaru the same deposit is largely developed, covering the volcanic rocks and extending northwards over the shingle-beds of the plains. It can be traced all the way down to Oamaru, where it is as well developed as at Timaru. But after crossing the Kakanui River we lose it; or, rather, it changes into an ordinary clay, with more iron in it than in the typical deposit. These brown clays extend through Dunedin and South Otago nearly to the mouth of the Mataura, where we again come across a silt exactly like that of Lyttelton, which continues over the Southland plains to Invercargill, and perhaps further—for I am

compelled to limit myself to my personal observations, not being able to find anything definite about this silt-deposit in the reports of the officers of the Geological Survey. I have mentioned the geographical distribution of the silt because it must have had the same mode of origin at Oamaru and Southland as on the Canterbury Plains, so that any theory respecting it must be suitable to all these places.

Its chemical composition is not yet accurately known, as no analysis has been made; but it consists of a mixture of clay and fine quartz sand, with very little iron or lime in it. The sand-grains are not much rounded—not so much as we should expect to find in a wind-blown deposit.

The most remarkable thing about this silt is its capillary structure; the mass of the rock being penetrated in all directions by minute tubules, very irregular in diameter, branching in all directions, and anastomosing with each other. Occasionally, but rarely, these tubules are filled with calcium-carbonate, and in one place, on Banks Peninsula, I found them containing limonite. On the slopes of Banks Peninsula the lower portions of the silt often contain small fragments of volcanic rocks evidently derived from the hills above. These are not found in the upper parts, where the deposit is thick, nor on the plains.

Fossils are very rare. On Banks Peninsula and on the hills of the Oamaru Peninsula moa-bones occur; and inland of Oamaru the skull of an elephant-seal was found many years ago: it is now in the Dunedin Museum. At Raupo Bay, near Little Akaloa, on the property of Mr. J. W. McHale, there are a number of concretions round bones in the silt, about 100 ft. above sea-level. They are numerous, and represent the remains of a very large animal. Most of them cannot now be recognised, but Mr. McHale showed me one which was evidently the first phalanx of the third or fourth finger of a large baleen whale. It was 6 in. long by 2½ in. in breadth at its contracted middle. Marine shells occur in abundance at the base of the deposit round the Oamaru Peninsula, and a few are said by Mr. McKay to have been found at Timaru. Also, at the Port Hills, near the Convalescent Home, Miss M. Bridges has found two specimens of a *Euthria* and one of a *Crepidula*.

At Lyttelton the silt is distinctly stratified near its base, and occasionally the same is seen near Timaru, but elsewhere its composition is too uniform to show any division into layers.

Now, as to its origin: It is, I think, evident that the material of the silt-deposit was brought down by the great rivers draining old glacier districts. It resembles closely the glacial mud which fills up some of the older lakes, as in the Rakaia Valley. Commencing a little north of the Waimakariri and ending a little

south of the Waitaki, and commencing again near the mouth of the Mataura and continuing, probably, to the mouth of the Waiau, it appears to be connected with the rivers which come down from the glaciers. We may perhaps ask why it is not found also at the mouth of the Clutha. In answer I would say that it has never been looked for in that district. And if it is really absent we should probably find an explanation in the alteration of the courses of some of the rivers in the interior of Otago.

But, granting that the material came down the rivers, how did it become diffused and spread out over the surface of the land near the embouchures of the rivers? Evidently it is not accumulating now, for it is covered up near Amberley by the gravels of the Kowhai; and it is everywhere being washed away by the rain. Also it is clear that it is not a river deposit, for it is too evenly spread, and a river could not possibly have taken it up the hills of Banks Peninsula. Hence we are driven to suppose that it must be either a marine or a wind-borne deposit. It must be one or the other—it cannot be both.

Sir Julius von Haast was the first advocate of the wind hypothesis.* After reading Richthoven's theory of the origin of the loess in China he came to the conclusion that our silt-deposit was also a loess, and had a similar origin to that of China; and in this opinion he was supported by Mr. J. Hardcastle.† Richthoven's theory is this: He supposes that in the arid interior of a large continent the decomposition of the rocks would produce a great quantity of dust, which would be blown away by the wind. On the outskirts of this arid district a more or less rainy district would be found where grass would grow. The grass would catch the dust, hold it together and grow over it, so that the dust would accumulate and form the deposit called loess. The capillary structure he thought to be due to the roots of the grass which had decayed away.

In applying this theory to a small island like New Zealand we meet with considerable difficulties. Where are we to find the desert area capable of producing so large an amount of dust? If we suppose that the land formerly extended much farther on each side of the mountains so as to make an arid area, how can we account for the absence of the silt from the interior of Otago and the neighbourhood of Dunedin? But the silt may have been brought down by the rivers and deposited in their beds, and may have been subsequently blown away as dust-storms over the plains. Here we have a possible source of dust in the old glacier muds, which did not require a desert to form them in. Let us

* "Geology of Canterbury and Westland," Christchurch, 1879, p. 367.
† Trans. N.Z. Inst., vol. xxii., p. 406, and vol. xxiii., p. 324.

therefore see whether the æolian origin will account for the deposit, and what is the evidence in its favour. First comes the capillary structure. But even a cursory examination shows that it in no way resembles the fibrous roots of grasses. The tubules do not radiate downwards from centres where the grass-plants should have grown; neither do they taper downwards like roots, but change rapidly and irregularly in diameter. And the anastomosing is very different from anything seen in roots. No doubt some of these tubules are now occupied by roots, which have grown into them; but they are comparatively rare, and evidently do not belong to the time of the formation of the tubules. Then we have the occurrence of moa-bones, and, as stated by Sir Julius von Haast, of land-shells. But the remains of both birds and land-shells are found in marine deposits, having been carried down by the rivers into the sea; and the most important evidence is the general absence of marine fossils, even at the base of the deposit. But there is also the difficulty of accounting for the entire absence of decaying vegetation and carbonaceous compounds, which ought to exist if the wind-borne theory is true. If grasses were constantly getting covered over with dust the deposit must at one time have contained nearly as much vegetable matter as sand. What has become of it all, and where are the marks of the former plants? Why should the deposit be full of the marks of roots and yet not have retained any marks of leaves, stalks, or fruit, which form the largest part of the plant? The question has only to be stated to show the inadequacy of the wind hypothesis.

On the other hand, the absence of marine fossils may have been due to the rapidity with which the deposit accumulated and the short time the land was submerged, so that shells and slow-moving animals could not people the constantly changing shore-line.

The evidences in favour of the marine origin of the silt are—first, the actual occurrence of marine fossils at Oamaru, Banks Peninsula, and perhaps at Timaru; secondly, its stratification at Lyttelton and Timaru; thirdly, its position on the crests of the hills; fourthly, the occurrence in it of pebbles too large for the wind to blow away; fifthly, its equal development on both the lee and weather sides of Banks Peninsula; and sixthly, the angular shape of the grains. None of these facts can be explained on the theory of the æolian origin of the silt, and its advocates have failed to bring forward any crucial evidence in its favour.

According to Professor Boehm of Freiberg, who visited New Zealand in 1899, this pseudo-loess, as he calls it, is certainly of marine origin at Oamaru. "Whether it is so everywhere in New Zealand must be decided by the examination of abundant

material; but [he says] I may here point out that on the east coast of this country most distinct traces of elevation are to be observed. Upon the road from Oamaru to Kakanui old marine boulders are to be seen everywhere, and distinct shore-terraces with deep erosion-furrows. They lie at a considerable height above high-water mark, and sometimes one above the other."*

Thus we see that the evidence in favour of the marine origin of the silt fits in with that derived, quite independently, from the structure of the Canterbury Plains, and the existence of raised sea-beaches at Amuri Bluff and other places. This conclusion is strengthened by the botanical evidence, as reported by Mr. T. Kirk and Dr. Cockayne, of sea-shore plants occurring inland at the base of the mountains. Sir Julius von Haast and Mr. Hardcastle take too local a view of the deposit, and neither of them examined it at Oamaru or in Southland. On the whole we may consider it as fairly well proved that the alluvial beds forming the Canterbury Plains were formed when the land stood considerably higher than at present, but was subsiding. The sinking continued until the land was perhaps nearly 1,000 ft. lower than now, when the silt-deposit was laid down, and then began to rise again.

Art. LI.—*Three New Tertiary Shells.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 3rd August, 1904.*]

Plate XLIV.

Pleurotoma hamiltoni. XLIV., fig. 1.

Shell elongato-fusiform, large, aperture occupying nearly half the length of the shell. No longitudinal ornamentation; whorls keeled. Spire long and sharp, of 10–11 whorls, the whorls shouldered, and ornamented below the shoulder with fine spiral striæ, more distinct in the upper than in the lower whorls. The shoulder of the upper 8 whorls with small tubercles, about 12 in a whorl. Suture with a row of raised points formed by the growth-lines. Spirals below the sinus 6 on the 7th whorl, 12 on the 9th whorl. Body-whorl nearly smooth, the spiral striæ being obsolete or altogether absent. Aperture narrow with a well-marked posterior, wide sinus, not very deep, rather broad, and not separated from the suture. Anterior canal long and straight.

* Zeitschr. d. Deutsch-geololog. Gesellschaft, 1900, 175.

Length, 120 mm.; width, 30 mm.; length of aperture, 54 mm.

Locality.—Waihao Forks. Collected by Mr. Harold Hamilton.

The type is in the Canterbury Museum.

Mitra hectori. Plate XLIV., fig. 2.

Shell elongato-fusiform, the aperture about as long as the spire. Pullus conical. Whorls of the spire 7 (not counting the pullus), nearly flat, separated by a channelled suture, with a rounded shoulder; smooth; ornamented with 3 distant, low, very obscure spiral ribs. Body-whorl with a low obscure spiral rib near the shoulder, and distinctly spirally ribbed at the base, the central portion smooth and rather flattened. Aperture narrow, outer lip thin; columella with 4 well-marked plaits, of which the posterior is rather the largest. There are no longitudinal striæ.

Length, 45 mm.; width, 13 mm.; length of aperture, 22 mm.

Locality.—Waihao, near the coal-mine. Collected by Mr. Aug. Hamilton.

The type is in the Canterbury Museum.

Pecten hilli. Plate XLIV., fig. 3.

Large, equivalve, rather compressed, equilateral, suborbicular. Ears large, equal, without any sinus; the posterior with 3, the anterior with 4 slightly undulating ribs. Right valve with about 30 narrow ribs, many of which are grooved in the ventral half of the shell, and slightly roughened by growth-lines. Interstices broader than the ribs, smooth, simple. The left valve is imperfectly preserved, but what can be seen of it does not differ much from the right valve.

Length, 4·55 in. (116 mm.); height, 4·25 in. (108 mm.); thickness, 1·55 in. (40 mm.).

Locality.—Napier, in limestone.

Allied to *P. triphooki*, but distinguished from that species by the narrower and more numerous ribs, which are not so scaly, as well as by the simple interstices.

The type is in the Canterbury Museum.

EXPLANATION OF PLATE XLIV.

Fig. 1. *Pleurotoma hamiltoni*, Waihao Forks.
Fig. 2. *Mitra hectori*, Waihao, near the coal-mine.
Fig. 3. *Pecten hilli*, Napier.

Art. LII.—*Revision of the Tertiary* Brachiopoda *of New Zealand.*

By Captain F. W. Hutton, F.R.S.

[*Read before the Philosophical Institute of Canterbury, 3rd August, 1904.*]

Plates XLV. and XLVI.

Terebratulina suessi.

Terebratulina, sp., Suess, Reise der "Novara," Palæ., p. 57, taf. ix., fig. 6. *T. suessi*, Hutton, Cat. Tertiary Moll. of N.Z., p. 37. *T. oamarutica*, Boehm, Zeitschr. d. Deutsch Geol. Ges. 1904, p. 148, pl. xv., f. 1–5.

Shell ovate, finely radiately striated; valves subequal; foramen large, incomplete. Ventral valve with a slight but broad depression, sometimes almost obsolete.

Length, 10 – 23 mm.; width, 7 – 17 mm.; thickness, 4–12 mm.

*Localities.**—Curiosity Shop; Kakanui.

The annulus of the loop is nearly circular and rather large. The shape of the shell is generally ovate, but variable. The striæ occasionally bifurcate. In shape it is hardly to be distinguished from *T. scouleri* of Tate, but the striations are rather stronger, and the foramen appears never to become complete.

Terebratula concentrica. Plate XLV., fig. 1.

Waldheimia concentrica, Hutton, Cat. Tertiary Moll. of N.Z., p. 35. *T. bulbosa*, Tate, Trans. Phil. Soc. Adelaide, 1880, p. 6, pl. vii., fig. 5. *T. oamarutica*, Boehm, Zeitschr. d. Deutsch Geol. Ges., 1904, p. 149, pl. xv., f. 6–7.

Shell ovate, the greatest breadth in front of the middle; with concentric growth-lines, or smooth. Both valves convex, the ventral more so. Commissure straight at the sides and with a slight dorsal sinuation at the anterior end (sometimes missing). Beak thick, obtusely keeled, or rounded, slightly produced; foramen complete, round, very large. Deltidium distinct but small. Loop rather long, stout, like that of *T. vitrea*.

Length, 37 – 42 mm.; width, 28 – 29 mm.; thickness, 21–23 mm.

Localities.—Kakanui; Broken River; Waipara. Cobden limestone.

Differs from the next species in the usually keeled beak, the upward sinuation of the commissure, and in being more attenuated posteriorly.

* These refer to the localities in the Canterbury Museum only.

Terebratula gravida.

T. tayloriana, Colenso, Tasmanian Journ. of Science, 1844 (not of Lea, 1841). *Waldheimia gravida*, Suess, Reise der "Novara," Palæ., p. 56, taf. ix., f. 5.

"Shell ovate, ventricose, very solid, smooth, concentrically and obsoletely striated, lamellar; margin apparently entire; summit of larger valve much produced, arcuated, subdeflexed, thick, very truncate; perforation large; horn or light mouse-colour. Length, 2½ in.; breadth, 1½ in." (Colenso.)

The shell is much inflated, the valves nearly equally convex. Beak short, thick, not keeled; the foramen very large; deltidium small, hidden. Commissure even, or slightly sinuated. Interior unknown.

Measurements of the specimens in the Museum: Length, 57–84 mm.; width, 38–70 mm.; thickness, 38–53 mm.

Localities.—Ngapara, near Oamaru; Broken River.

Magellania lenticularis.

T. lenticularis, Deshayes, Mag. Zool., 1841, pl. xii. *Waldheimia lenticularis*, Adams, Gen. of Recent Moll., ii., 575.

Orbicular, inflated, the commissure nearly straight. Beak small, incurved, laterally keeled; foramen small or moderate; deltidium conspicuous, the internal margins of the two deltidial plates forming a groove.

Magellania lenticularis, var. ovalis. Plate XLV., fig. 2.

Waldheimia ovalis, Hutton, Trans. N.Z. Inst., vol. xviii., p. 335.

More elongated than the typical form.

Length, 44 – 53 mm.; width, 35 – 40 mm.; thickness, 21–28 mm.

Locality.—Wanganui (type).

Magellania novara. Plate XLV., fig. 3.

Wald. lenticularis, Suess, Reise der "Novara," Palæ., p. 56, taf. x., f. 3–4 (not of Deshayes). *M. novara*, H. v. Jhering, Ann. del Mus. Nac. de Buenos Aires, ix., p. 337 (1903).

Orbicular, rather depressed, valves nearly equally convex, smooth, the greatest breadth rather behind the middle; commissure nearly straight. Beak moderate, laterally keeled; foramen small; deltidium conspicuous, the inner margins of the deltidial plates forming a groove.

Length, 49 mm.; width, 44 mm.; thickness, 25 mm. Interior unknown.

Localities.—Waipara; Weka Pass district.

Distinguished from the last species by being less inflated.

Magellania parki, sp. nov. Plate XLV., fig. 4.

Oval or suborbicular, smooth; valves nearly equal, rather depressed; beak short, sharply keeled laterally; the inner margins of the deltidial plates forming a groove. Ventral valve flattened at the sides. Commissure with a strongly marked downward (ventral) sinuation.

Length, 25 – 37 mm.; width, 26 – 29 mm.; thickness, 13–17 mm.

Localities.—Oamaru (type); Waipara.

The septum is thick and less than half the valve. Several specimens connect this with the last species, but the type is very different.

Magellania insolita. Plate XLV., fig. 5.

M. insolita, Tate, Trans. Phil. Soc. of Adelaide, 1880, p. 12, pl. ix., fig. 6.

Medium, oval, the greatest breadth before the middle. Smooth except a few growth-lines, moderately convex, commissure nearly straight. Beak slightly incurved, obscurely keeled laterally; foramen complete, round, medium. Deltidium rather small, the two plates not united.

Length, 21 – 28 mm.; width, 17 – 24 mm.; thickness, 10–16 mm.

Localities.—Duntroon; Curiosity Shop.

Separated from *M. novara* by its shape, and from *M. lenticularis* by being depressed. It is also smaller than either. Doubtfully identified, as Professor Tate's description is insufficient, and I have no Australian specimens.

Magellania sufflata. Plate XLVI., fig. 1.

Wald. sufflata, Tate, Trans. Phil. Soc. of Adelaide, 1880, p. 18, pl. vii., fig. 3, and pl. viii., fig 4.

"Shell subovate, greatest width about the middle; lateral margins convex in the middle, becoming straight or slightly bisinuated (rarely biplicate) towards the narrow rounded front. Test thick, surface smooth, with numerous moderately strong lines of growth. Shell-structure minutely and closely punctate as viewed under a lens. Peduncular valve very convex in a longitudinal direction, and regularly convex transversely. Beak strongly incurved, slender; foramen minute. Deltidium of one piece, broadly triangular and deeply concave. Brachial valve very convex, faintly impressed or flattened medially, becoming gradually depressed in the middle towards the somewhat narrowed front. Septum a little less than half the length of the valve. Loop unknown." (Tate.)

The following are the dimensions of two New Zealand specimens. Length, 76–81 mm.; width, 53–63 mm.; thickness, 46–50 mm.

Locality.—Weka Pass district.

Distinguished by its strongly incurved beak with minute foramen, and deltidium of a single piece. The beak is slightly keeled. *Terebratella venter*, Jhering, from the Miocene beds of Santa Cruz in Patagonia, is an allied form.

Magellania triangularis.

Wald. triangularis, Hutton, Cat. Tertiary Moll. of N.Z., p. 36. *T. angulare*, Hector, Outlines of Geol. of N.Z., p. 54, fig. 11.

Shell orbicular, smooth, inequivalve. Ventral valve with the sides more or less flattened. Anterior margin of the commissure with a broad downward (ventral) sinuosity. Beak much incurved, the former small. Deltidium small, almost hidden, of one piece; the beak slightly keeled.

Length, 51–53 mm.; width, 48 mm.; thickness, 29–32 mm.

Locality.—Waitaki Valley.

Distinguished from the last species by the flattened sides of the ventral valve and being less inflated. It differs from *M. coriensis*, McCoy, in the greater relative breadth and in the flatter dorsal valve.

Terebratella sanguinea.

T. sanguinea, Leach, Zool. Misc. p. 76. *T. cruenta*, Dillwyn; Reeve, Conch. Icon., fig. 20.

Ventricose, ornamented with radiating dichotomous ribs; about 25–30 in the centre of each valve in the adult. Margins crenulated; dorsal valve with a central longitudinal depression. Beak somewhat produced, laterally keeled. Foramen large, complete; deltidium large.

Length, 38 mm.; width, 38 mm.; thickness, 25 mm.

Localities.—Wanganui; Kakanui (?), small specimen.

Terebratella novæ-zealandiæ.

T. dorsata, Suess, Reise der "Novara," Palæ., p. 57, taf. xiv., fig. 5 (not of Gmelin). *T. novæ-zelandiæ*, H. v. Jhering, Ann. Mus. Nac. de Buenos Aires, ix., p. 328, 1903.

This species is not represented in the Museum collection.

Terebratella radiata. Plate XLVI., fig. 2.

T. radiata, Hutton, Trans. N.Z. Inst. xix., p. 406 (1887).

Broadly ovate, with a deep ventral ridge and dorsal sinus. Surface with strong radiating ribs, about 18 on the ventral

valve, of which 4 or 5 are on the ridge; imbricated with coarse growth-lines. Punctuations fine, rather distant from each other. Beak prominent, acute; foramen subtriangular; the deltidial plates disunited.

Length, 13 mm.; width, 12 mm.; thickness, 8–10 mm.

Locality.—Broken River (type).

Distinguished from the last species by its strong rough ribs and more acute beak, as well as by the deeper sinus on the dorsal valve. Its general appearance is much like a *Rhynchonella.*

Terebratella rubicunda.

T. rubicunda, Solander, MS., Donovan, Nat. Rep., p. 56, figs. 2–5. *T. sanguinea*, Quoy and Gaimard, Voy. "Astrolabe," Zool. iii., p. 556, pl. 85, figs. 6–7 (not of Leach).

"Shell somewhat triangularly ovate; beak tumidly produced, deltidium divided. Valves gibbous, flexuosely channelled in the middle." (Reeve.)

Length, 19 mm.; width, 18 mm.; thickness, 10 mm.

Locality.—Wanganui.

Recognised by its well-marked anterior sinuation.

Terebratella furculifera.

T. furculifera, Tate, Trans. Phil. Soc. Adelaide, 1880, p. 22, pl. xi., fig. 7.

Shell small, suborbicular, smooth, rather longer than wide, rather depressed, valves equally convex, commissure nearly straight. Beak short, not much incurved, obtusely keeled. Foramen small, incomplete; deltidial plates well marked, disunited. Septum less than half the length of the valve.

Length, 16 mm.; width, 13 mm.; thickness, 8 mm.

Localities.—Curiosity Shop; Weka Pass district.

I have compared New Zealand with Australian specimens, and can find no difference of sufficient importance to separate them.

Terebratella sinuata.

Wald. sinuata, Hutton, Cat. Tertiary Moll. of N.Z., p. 36.

Shell orbicular-trigonal, smooth, valves unequal; beak very short, deltidium hidden. Ventral valve with a broad marginal sinus; dorsal valve convex, margin much sinuated.

Length, 25 mm.; width, 26 mm.; thickness, 13 mm.

Not represented in the collection in Canterbury Museum.

Like the last species in general shape, but distinguished from it by the flatness of the ventral valve, which is not so convex as the dorsal valve.

Terebratella neglecta, sp. nov. Plate XLVI., fig. 3.

T. aldingæ, Hutton, Trans. N.Z. Inst., xix., p. 406 (not of Tate).

Shell small, ovate, the greatest breadth usually before the middle, smooth, rather depressed; dorsal valve but slightly convex; commissure straight. Beak moderate, not much incurved, without lateral keels. Foramen moderate, complete, round; deltidium small, almost hidden, but solid. Interior unknown.

Length, 12 mm.; width, 9 mm.; thickness, 6 mm.

Locality.—Curiosity Shop (type).

I formerly confused this with *T. aldingæ* of Tate, but after comparison with specimens of that species, kindly sent me by Professor Tate, I find that it is narrower, and that the beak is not so much produced.

Terebratella kakanuiensis, sp. nov.

Small, ovate, the sides nearly straight, smooth, rather inflated. Both valves considerably curved longitudinally. Commissure straight. Beak moderate, incurved, not laterally keeled. Foramen moderate; deltidium hidden. Interior unknown.

Length, 10 mm.; width, 8 mm.; thickness, 6 mm.

Locality.—Kakanui (type).

Distinguished by its inflated form and much incurved beak.

Terebratella gaulteri. Plate XLVI., figs. 4 and 5.

T. gaulteri, Morris, Quart. Journ. Geol. Soc., vi., p. 329.

"Shell subtriangular, smooth, both valves nearly equal and rather depressed; lateral margins sinuous; ventral valve with an acute and slightly recurved beak, the foramen below it; the anterior margin with a broad sinus, producing a corresponding arched elevation in the smaller valve." (Morris.)

Length, 21 mm.; width, 20 mm.; thickness, 10 mm.

Ovato-trigonal, greatest breadth before the middle. Commissure with a strong upward (dorsal) sinuation at the anterior end. Beak very small, slightly keeled; foramen minute; deltidium obscure. Interior unknown.

Locality.—Curiosity Shop; Cobden limestone.

Easily recognised by its small beak and the upward anterior sinuation.

Terebratella oamarutica.

T. oamarutica, Boehm, Zeitsch. d. Deutsch Geol. Ges. 1904, p. 149, pl. xv., f. 9.

Described from the loop only.

Bouchardia tapirina. Plate XLVI., fig. 6.

Wald. tapirina, Hutton, Cat. Tertiary Moll. of N.Z., p. 36.
Wald. sp., Hector, Outlines of Geol. of N.Z., p. 56, f. 8.

Shell suborbicular, smooth; valves depressed, nearly equally convex. Beak produced, slightly curved, laterally keeled. Foramen minute; deltidial area large and solid. Interior unknown.

Length, 22–40 mm.; width, 20–36 mm.; thickness, 13–16 mm.

Localities.—Mount Somers limestone; Curiosity Shop; Oamaru.

B. zittelli, Jhering, from Santa Cruz in Patagonia, differs in having a well-marked anterior sinuation.

Bouchardia rhizoida, sp. nov. Plate XLVI., fig. 7.

Shell ovato-pentagonal or oval, longer than wide, smooth. Dorsal valve more inflated posteriorly than the ventral, but anteriorly they are equally flattened. Commissure nearly straight. Beak much produced, slightly incurved, laterally keeled; foramen small; deltidium large, triangular, solid. Interior unknown.

Length, 32–44 mm.; width, 24–32 mm.; thickness, 17–23 mm.

Localities.—Weka Pass district (type); Oamaru.

Distinguished from the last species by its shape and greater thickness.

Rhynchonella nigricans.

R. nigricans, Sowerby, Davidson, Proc. Zool. Soc. 1872, abstr., p. 7, pl. i., figs. 30, 31; Suess, Reise der "Novara," Palæ., p. 60, taf. xiv., fig. 4.

Shell thin, wider than long, but very irregular in shape; margin crenulated, commissure sinuated. Longitudinal ribs about 20–25 in each valve.

Length, 19 mm.; width, 21 mm.; thickness, 10 mm.

Localities.—Wanganui; Curiosity Shop.

Rhynchonella squamosa.

R. squamosa, Hutton, Cat. Tertiary Moll. of N.Z., p. 37; Tate, Phil. Soc. Adelaide, 1880, p. 27, pl. ix., fig. 9. *R. nigicrans*, var. *pixydata*, Davidson, "Challenger Reports," vol. i., p. 59, pl. iv., f. 14.

Shell irregular, more or less orbicular, generally transverse. Valves unequal, the ventral flatter and with a deep sinus; dorsal valve very convex; both with fine radiating scaly striæ.

Length, 17 mm.; width, 19 mm.; thickness, 13 mm.

Locality.—Broken River.

Easily distinguished from the last by its finer and more numerous ribs. I have seen very large fossil specimens from Patagonia. It is still living south of Kerguelen Island.

EXPLANATION OF PLATES.

PLATE XLV.

Fig. 1. *Terebratula concentrica*, Broken River.
Fig. 2. *Magellania lenticularis*, var. *ovalis*, Wanganui.
Fig. 3. *Magellania novara*, Weka Pass district.
Fig. 4. *Magellania parki*, Oamaru.
Fig. 5. *Magellania insolita*, Duntroon.

PLATE XLVI.

Fig. 1. *Magellania sufflata*, Canterbury.
Fig. 2. *Terebratella radiata*, Broken River.
Fig. 3. *Terebratella neglecta*, Curiosity Shop.
Fig. 4. *Terebratella gaulteri*, Curiosity Shop.
Fig. 5. *Terebratella gaulteri*, Cobden limestone.
Fig. 6. *Bouchardia tapirina*, Curiosity Shop.
Fig. 7. *Bouchardia rhizoida*, Weka Pass district.

ART. LIII.—*Magnesian Rocks at Milford Sound.*

By Dr. P. MARSHALL.

[*Read before the Otago Institute, 13th September, 1904.*]

Plate XLVII.

THE remarkably wide occurrence of magnesian rocks in New Zealand has often been remarked upon. The well-known Dun Mountain region was described by Hochstetter in 1865. In 1887 the reports of the Geological Survey of New Zealand contained a paper by Professor Park on the Big Bay district, where a very large mass of these rocks constitutes the Red Hill Range and some neighbouring portions of the coastal regions. This district was more fully described by the late Professor Ulrich in the *Quarterly Journal of the Geological Society* of 1890, when the occurrence of the nickel-iron alloy awaruite in these rocks was first mentioned.

A small occurrence of these rocks, hitherto only briefly referred to in Hutton's "Geology of Otago," has long been known to exist at Milford Sound, but beyond the fact that bowenite was found there little more has been known. A recent visit to Anita Bay, at the entrance to Milford Sound, enabled the author to make a cursory examination of the district, and bring away specimens for microscopical and chemical investigation.

At the east end of the bay there is a large outcrop of gneissic granulite, much contorted. A small beach separates this from a mass of dunite about 150 ft. wide, striking apparently S. 80° W., and dipping 70° S. The dunite is per-

fectly fresh beyond a certain amount of reddish weathered crust. It contains grains of chromite and occasionally small crystals of diopside.

To the west of the dunite no rocks are to be seen *in situ*, but huge boulders of granulite and hornblende schist form the beach, and probably indicate that these rocks succeed the dunite in this direction. The granulite extends about a quarter of a mile, and thereafter the beach consists for 400 yards of a light greenish-grey serpentine, with occasional unaltered grains of olivine and some small veins of bowenite* running through it. The serpentine gives place further on to a beach of small pebbles, which is about 300 yards long. Another mass of boulders is then found, and then another small beach followed by granulite, much contorted, *in situ*.

Among the boulders between the two beaches just mentioned were several boulders of hartzbergite, in which the enstatite crystals stand out from the weathered surface. They are sometimes 6 in. wide by as much as 2 in. broad.

Another large boulder, weighing about 100 tons, was found still further west than the granulite outcrop just described.

So far as these geological indications afford evidence, it seems probable that there is a large intrusion of dunite, some part of which is changed to serpentine with veins of bowenite. The hartzbergite appears to form another intrusion of smaller size further west.

These rocks were examined, with the following results :—

Bowenite.

Hand-specimen clear transparent green, with a splintery fracture and small opaque inclusions. Microscopically a dense mesh of minute needles of colourless transparent serpentine, occasional small unaltered cores of olivine, and some grains of chromite.

Dunite. (Plate XLVII., fig. 1.)

Hand-specimen pale olive-green rock, very dense, but showing occasionally small crystals of chromite, some bright cleavage-surfaces of diopside, and rounded larger grains of olivine.

Section.—The large olivine grains have undulose extinction, and are imbedded in a mass of olivine grains with irregular-fractured boundaries evidently produced by crushing. The whole structure is distinctly cataclastic. The diopside is perfectly transparent, with good cleavage, and extinction angle over 40°. Chromite barely transparent, with a brown colour. No indication of serpentinisation of the olivine.

* This mineral is mined from an adit 1,500 ft. above sea-level.

Hartzbergite. (Plate XLVII., fig. 2.)

Hand-specimen pale-green rock with fine large bright cleavage surfaces of enstatite, and between them granular olivine. Scattered dark grains of iron-ore.

Section.—Enstatite in large perfectly colourless transparent plates showing good cleavage-traces. The plates include poecilitic grains of olivine and iron-ore, and in some sections a great deal of a carbonate showing rhombohedral cleavage. As the analytical results give no calcium in the rock, this carbonate must be magnesite. Its birefringence is similar to that of calcite, giving even in thin sections colours and even white of the higher order. The iron-ore is metallic in reflected light, and absolutely opaque even in the thinnest section. No cleavage discernible. Attacked by HCl, so apparently magnetite. The alteration of enstatite into magnesite appears rather peculiar. All the rocks found as boulders have evidently rolled down in stream-channels and landslips from the hillsides that are thickly covered with forest. The change may be due to the fact that percolating waters are more than usually charged with organic acids derived from the mass of decaying vegetable matter that forms the surface soil.

A partial chemical analysis was made of the hartzbergite, with the following result:—

	A.	B.	C.
SiO_2	30·00	39·99	41·43
Al_2O_3 ...	...	3·55	0·04
Fe_2O_3 ...	5·76	...	2·52
Cr_2O ...	2·30	...	0·76
FeO^3	2·40	8·56	6·25
CrO	0·48	...	...
MgO	45·48	41·26	43·73
CaO	...	4·19	0·55
Loss	13·36	2·07	4·51
Total ...	99·78		

A. Hartzbergite, Milford Sound; anal., P. Marshall. B. Hartzbergite, Olivine Range, N.Z., Q.J.G.S., 1890. C. Hartzbergite, Oregon County, U.S.A.

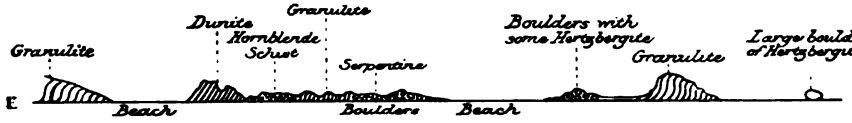
In this analysis the high percentage of loss is evidently due to the presence of magnesite. The iron-oxides and chromium-oxides are at present only approximately estimated, for ordinary methods of separating these substances fail. The iron-ore has been separated by magnetic means, and the total quantity of iron-oxides and chromium-oxides estimated. The ore completely dissolves in HCl. This must indicate that

some chromous oxide at least is present, but I have not yet satisfactorily estimated what quantity of it is present.

The analysis of the other hartzbergites given above shows that this rock, except for the magnesite, is a very pure sample. Its composition seems to be,—

Magnesite ...	...	28·12	13·36 CO_2 14·76 MgO
Olivine ...	...	36·42	16·37 SiO_2 20·05 MgO
Enstatite ...	...	24·30	14·85 SiO_2 9·45 MgO
Magnetite (chromous)		10·09	
Total	...	98·93	

The present occurrence is evidently closely connected with that at Red Hill, whence the rock (analysis B) came, and dunite has also been reported from the same district, as well as serpentine and bowenite. The relations of these rocks to surrounding deposits, as well as their age, still remain a problem, though the Geological Survey has referred them with some confidence to the Devonian period. The high specific gravity—3·2 in this case, and 3·35 in some of the Red Hill rocks—shows that these rocks are properly resident at an enormous depth from the surface, so some specially potent tectonic disturbance, whose nature will, we hope, be afterwards unravelled by New Zealand geologists, must have been necessary to bring these rocks to the earth's surface. It is perhaps of interest to add that no trace of awaruite was found in the rocks or sands of the Milford Sound magnesian rock district, and only a faint trace of Ni could be obtained chemically.



Section one mile and a half long of Anita Bay, south side of Milford Sound, near entrance.

EXPLANATION OF PLATE XLVII.

Fig. 1. Dunite. Shows cataclastic structure of rock. A large crystal of chromite is in the centre of the irregularly shaped broken fragment of olivine crystals.

Fig. 2. Hartzbergite. A large plate of enstatite encloses pieces of iron-ore and rounded grains of olivine showing a distinct poecilitic structure. No magnesite is shown in the photograph.

ART. LIV.—*Description of a New Species of* Pecten *from the Oamaru Series.*

By Professor JAMES PARK, F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 9th August, 1904.*]

Pseudamussium (Pecten) huttoni. (Plate xi., fig 5A, "Reise der 'Novara,'" Paläontologie, bd. i.)

1873: *Pecten hochstetteri*, Hutton, Cat. Tert. Moll. N.Z., p. 30.
1897: *Pseudamussium hochstetteri* (?) Zittel; Harris, Cat. Tert. Moll. Brit. Mus., part i., p. 323.

Suborbicular, equivalve, equilateral, thin, compressed; both valves smooth; ears subequal, obtuse, smooth.

Dimensions.—Height, 80 mm.; length, 76 mm.

Formation.—A characteristic form of the Oamaru series of Miocene or Oligocene age. It ranges from the marine greensands overlying the Tertiary coal to the summit of the Oamaru stone. It has never been found above or below the Oamaru series.

Localities.—Winton, Milburn, Clarendon, Caversham, Waitati, Waikouaiti, Hampden, Maheno, Kakanui River, Awamoa Creek, Oamaru Creek, Totara, Ngapara, Enfield, Black Point, Duntroon, Marawhenua, Wharekuri, Waihao Forks, Pareora Gorge (lower end), White Rock River, Tengawai, Kakahu, Castle Rock, Waipara, Mount Brown, Mount Donald, Point Elizabeth, Cape Farewell, West Whanganui, Mokau, Raglan, Aotea, Whangarei, Paparoa, Pahi.

Remarks.—For the past thirty years this beautiful shell has been known to geologists as *Pecten hochstetteri*. It is easily distinguished from *P. hochstetteri*, which is radiately ribbed on the right valve, smooth on the left valve, and in mature specimens does not exceed a height of 56 mm. and a length of 54 mm.

In plate xi., fig. 5A, a right valve of *P. huttoni* is figured in error as the smooth valve of *P. hochstetteri*. It was doubtless this error which originally led to the confusion with respect to the two species.

Art. LV. — *On the Cause of Border-segregation in some Igneous Magmas.*

By Professor James Park, M.A.Inst.M.E., M.Inst.M.M., F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 13th September, 1904.*]

It has been ascertained by microscopic investigation that nearly all igneous rocks vary in composition in different parts, due to the aggregation of certain minerals in clusters, which vary in size from the smallest dimensions up to large rock-masses. Dr. W. C. Brögger and Professor J. H. L. Vogt were the first to direct attention to the fact that igneous rocks are generally more basic near their borders than in the interior of the mass. It is found that the heavier minerals that first crystallize from the magma—namely, magnetite, olivine, chromite, hornblende, pyroxene, &c.—are principally concentrated in the outer portions of the igneous body.

Many valuable deposits of magnetite and chromite occur as border-segregations, and for this reason much discussion has taken place among mining geologists as to the force or energy concerned in the migration of these minerals from one part of the magma to another. The subject is one having a profound bearing upon magmatic differentiation generally.

For years it was commonly believed that border-aggregation was due to molecular flow, in accordance with Soret's principle that molecular concentration may be caused by difference of temperature—that is, in a homogeneous solution unequally heated in different parts concentration will be greatest in the region of lowest temperature.

A. Harker* and G. F. Becker† have contended that molecular flow in a cooling magma is too slow in its operation to be the cause of magmatic differentiation. And more lately Becker‡ and T. E. Spurr,§ simultaneously and independently, have argued that the migration and concentration of the first crop of heavy minerals near the borders, to a greater or less extent, may be due to convection currents resulting from differences of temperature. But even this hypothesis does not seem quite satisfactory. In the case of an eruptive magma in finite mass confined between walls, the direction of the convection currents in the central portion would be upward

* A. Harker, Quart. Journ. Geol. Soc., London, vol. i., 1894, p. 311.

† G. F. Becker, "Some Queries on Rock Differentiation," Amer. Journ. Sci., Jan. 1897, vol. iii., p. 21.

‡ G. F. Becker, "Fractional Crystallization of Rocks," Amer. Journ. Sci., Oct., 1897, p. 257.

§ J. E. Spurr, "Igneous Rocks as related to Occurrence of Ore," Trans. Aust. Inst. Ming. Eng., vol. xxxiii., 1903, p. 288.

and outward, and in the outer portion downward and inward. This cycle of flow would apparently be as likely to form central as border aggregations, or aggregations only in the outer lower limits of the magma.

Convection currents even in a very liquid magma would be very slow, except there was a constant accession of heat from below in amount greatly above that normal to the depth. Of such an accession in the case of a magmatic mass forming either a dyke or laccolite there is no evidence whatever.

I am inclined to ascribe border-segregation mainly to differences of osmotic pressure in the magma, with perhaps convection currents as a contributing cause. Osmotic pressure is a form of energy of great intensity. When precipitation takes place from a homogeneous solution of dissolved salts it instantaneously establishes a condition of equal concentration throughout the whole mass.

It may be urged, and not without reason, that an igneous magma is not a homogeneous body in the same sense that a solution of auro-potassic cyanide is said to be homogeneous. For a magma is composed of watery vapour, various gases, and a solution of solid constituents. It forms, however, a two-phase system the constituents of which are homogeneous in themselves, and consequently in a state of equilibrium at constant temperature and pressure.*

According to Van t'Hoff's law, the osmotic pressure of a substance in solution is the same pressure which that substance would exert were it in gaseous form at the same temperature, and occupying the same volume.

That is, $p = \frac{Rt}{V}$

where p = osmotic pressure in pounds per square inch ;
R = the gas constant = 1,206 lb. per square inch ;
t = absolute temperature, centigrade ;
V = volume of the solvent containing one molecular weight of the solute.

And $V = \frac{100\,M}{r}$

where M = the sum of the atomic weights of the atoms in a molecule of the dissolved substance ;
r = the strength per cent. of the solution.

Therefore $p = \frac{1206\,(t^\circ + 273)r}{100\,M}$

or $p = \frac{12r\,(t^\circ + 273)}{M}$

*Professor W. Ostwald, "Elements and Compounds," Faraday Lecture delivered before the Fellows of the Chemical Society in the Theatre of the Royal Institution, London, 19th April, 1904.

For example, the osmotic pressure of a 1-per-cent. solution of auro-potassic cyanide ($AuKCy_2$) at a temperature of 20° C. is as under :—

Here $r = 1{\cdot}0$

and $M = (197 \times 1) + (39 \times 1) + (26 \times 2) = 288$

then $p = \frac{(12 \times 1)\ (20 + 273)}{288}$

therefore $p = 12{\cdot}21$ lb. per square inch.

The osmotic pressure for a 4-per-cent. solution is 48·84 lb. per square inch, and for a 10-per-cent. solution 122·1 lb.

If we regard a molten magma as a mass of rock-material in solid solution, it is manifest that the separation of the first crop of minerals will result in a disturbance of the condition of equilibrium—for we know that the osmotic pressure varies directly as the concentration—and osmotic energy will at once exert itself to again establish a state of equal concentration throughout the magmatic solution.

The temperature at the borders of the magma will be less than that in the interior; and, since osmotic pressure varies directly as the temperature, it follows that the osmotic pressure will be less at the borders than in the interior. But osmotic pressure holds good for the Boyle-Henry laws and the law of Avogadro, and must therefore hold good for the laws of thermo-dynamics.* Hence there will be a transference of osmotic energy from the interior to the borders. The minerals first crystallized will be inert, and, being unable to offer ionic resistance, will be carried towards the cooler parts of the magma—that is, towards the borders.

Manifestly this unequal struggle between different potentials of osmotic energy will continue so long as the difference of temperature exists; but a point will be reached where the pressure will be neutralised by the increasing viscosity of the magma.

The minerals which first crystallize are generally basic, and these being carried outward as they form necessarily leaves the interior more siliceous or acid than the borders.

Further, it seems not improbable that molecular concentration,† in accordance with the Ludwig-Soret principle, may be the result of osmotic pressure due to unequal temperature in a homogeneous solution.

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* Lord Rayleigh, "The Theory of Solution," Scientific Papers, Cambridge Press, vol. iv., 1903.

† J. H. van t'Hoff, "The Role of Osmotic Pressure in the Analogy between Solutions and Gases," "The Modern Theory of Solution," New York, 1899, p. 21.

ART. LVI.—*On the Marine Tertiaries of Otago and Canterbury, with Special Reference to the Relations existing between the Pareora and Oamaru Series.*

By Professor JAMES PARK, M.A.Inst.M.E., M.Inst.M.M., F.G.S., Director Otago University School of Mines.

[*Read before the Otago Institute, 13th September, 1904.*]

Plate XLVIII.

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INTRODUCTION.

Ever since 1870 there has been a difference of opinion among New Zealand geologists as to the sequence and relations of the members of the marine Tertiaries of Otago and Canterbury, and it is not a little surprising that no general

agreement has yet been arrived at upon a subject which is of supreme scientific and economic importance to the colony.

The chief points of disagreement have mainly centred around the stratigraphical position of the beds which contain the Pareora fauna. The views of different writers have involved so many points of radical disagreement that it has been impossible for students of New Zealand geology to reconcile the differences.

In the hope of throwing some light upon this difficult problem I spent two months of the present year in an extended examination of the typical sections throughout North Otago and Canterbury, beginning at Hampden and ending at Waipara.

As the subject was largely palæontological I made considerable collections of fossils, which, with the exception of the brachiopods, I afterwards named by comparing them with the Tertiary types in the Canterbury Museum, all of which had recently been renamed by Captain Hutton, F.R.S., in accordance with latest nomenclature adopted in Europe.

The brachiopods in my collections were named by Captain Hutton, who kindly supplied the revised names as they appear in his paper on "The Revision of the Tertiary *Brachiopoda* of New Zealand." (See p. 474 of this volume.)

Altogether over twelve hundred fossils were examined and named. Without the aid of Captain Hutton this would have been a stupendous task; but the work was rendered comparatively easy through the unrivalled knowledge which he possesses of our Tertiary *Mollusca*.

Historical.

The name Pareora was first used in 1864 by Sir Julius von Haast* to designate certain fossiliferous marine beds in the valleys of the Pareora, Opihi, and Otaio Rivers in South Canterbury, as well as the Motanau and Greta beds in North Canterbury. Captain Hutton† subsequently, in his report on the geology of Marlborough and north-east district of Canterbury, in 1873, introduced the Pareora formation into his table of formations, assigning it at this time to the Upper Miocene. Like Haast, he referred the Motanau and Greta beds to this formation; but afterwards, in 1888, as the result of a more complete knowledge of the fossil contents of the different beds, he divided the Pareora formation into an upper and lower group, the former including the Greta beds, which contained about 66 per cent. of living forms.‡

The Pareora series of Captain Hutton now comprises

* Haast, "Geology of Canterbury and Westland," 1879, p. 323.
† Reports of Geol. Explorations, 1872–73, p. 47.
‡ Trans. N.Z. Inst., vol. xx., 1888, p. 262.

the Kakahu, Pareora River, Waihao Forks, Awamoa, and Hampden beds, all of which, he contends, contain a closely related fauna, of which some 37·5 per cent. are living species.* The Pareora series of the Geological Survey embraces the Greta, Pareora River, Mount Harris, and Awamoa beds; but excludes the Kakahu, Waihao Forks, and Hampden beds, which are placed below the Oamaru stone.

The present position is therefore as follows: According to Captain Hutton all the beds which contain the characteristic Pareora fauna are of Lower Miocene age, and are believed by him to overlie the Oamaru stone, often unconformably.† According to the Geological Survey the Pareora and Awamoa beds are believed to be of Lower Miocene age, and to overlie the Oamaru stone unconformably; while the Kakahu, Waihao Forks, Black Point, and Hampden beds, also containing a Pareora fauna, are admitted to underlie the Oamaru stone conformably.

GENERAL CONCLUSIONS.

(1.) That there are two limestones in the Oamaru series where the sequence is complete, separated by the Hutchinson Quarry beds and its associates. The upper limestone is a yellowish-brown calcareous sandstone characterized by such fossils as *Meoma crawfordi*, *Cirsotrema browni*, and *Pseudamussium huttoni*. It is the closing member of the series in Otago, Canterbury, and throughout the North Island. The lower limestone is the well-known Oamaru building-stone, typically developed in the Oamaru district. It is absent in South Otago, Waitaki Valley, Waihao, and Kakahu, but is represented by limestones in the Trelissic basin and Waipara district. A consideration of its distribution in the Oamaru district shows that it gradually decreases in thickness towards the west, dwindling to nothing long before the old shore-line is reached. In other words, it is a deposit formed in comparatively deep, clear water. For the upper limestone I propose to use the name Waitaki Stone, and for the lower Oamaru Stone. The Geological Survey and Captain Hutton, recognising only one limestone in the Oamaru district, have applied the name Oamaru or Ototara Stone indifferently to both the upper and lower limestones, which has naturally led to a good deal of confusion with respect to the relations of the Hutchinson Quarry and associated beds to the Waitaki Stone. Of the geologists who have examined North Otago, Mr. McKay was the only one to recognise two limestones. His view is that the Oamaru building-stone is the closing member of the Oamaru series, and that the Waitaki Stone and under-

* Hutton, "Geology of Otago," 1875, p. 58.
† Hutton, Trans. N.Z. Inst., vol. xxxii., 1899, p. 171.

lying Hutchinson Quarry beds are members of a younger series.

(2.) That the Awamoa and Hutchinson Quarry beds are the upper and lower members of the same series, and lie below the Waitaki Stone and above the Oamaru building-stone.

(3.) That the Hampden, Awamoa, Waihao Forks, Pareora, and Kakahu beds belong to the Oamaru series.

(4.) That Captain Hutton was right in separating the Motanau beds from the Pareoras.

(5.) That the Motanau beds overlie the Oamaru series unconformably.

(6.) That the Geological Survey is right in placing the Kakahu, Waihao Forks, Black Point, and Hampden beds below the Waitaki Stone, but wrong in ascribing the Pareora, Mount Harris, and Awamoa beds to a position above the Waitaki Stone, and wrong in correlating the Motanau and Pareora beds.

(7.) That the Pareora fauna is only found in beds underlying the Waitaki Stone.

(8.) That nowhere in Otago or Canterbury are beds containing the Pareora fauna to be seen overlying the Oamaru series.

(9.) That there are two horizons of littoral shells in the Oamaru series—namely, the Awamoas, lying above the Hutchinson Quarry beds, and the Waihao Forks beds, overlying the coal.

(10.) That the Oamaru series at Weka Pass rests unconformably upon the Weka Pass Stone.

(11.) That the Weka Pass Stone is conformable to the Amuri limestone, and is the closing member of the Waipara series in Canterbury.

(12.) That the Motanau and Awatere beds belong to the Te Aute series of Older Pliocene age.

Grouping the beds in the order of their superposition and according to their relationships, we get the following table of formations:—

Older Pliocene	..	Te Aute series	Motanau beds.
Miocene	..	Oamaru series	*a*. Waitaki Stone. *b*. Awamoa beds. *c*. Mount Brown beds. *d*. Oamaru Stone. *e*. Waihao sandstone. *f*. Awamoko shales, grits, and conglomerates, with brown coal.
Upper Cretaceous	..	Waipara series	*a*. Weka Pass Stone. *b*. Amuri limestone. *c*. Waipara greensands. *d*. Saurian beds. *e*. Puke-iwi-tahi fireclays, grits, and conglomerates, with coal.

The Motanau beds, containing some 70 per cent. of living forms, rest unconformably upon the Mount Brown beds, as will be shown later on. They contain none of the large extinct molluscs which characterize the Pareora and Awamoa beds.

The Pareora beds are nowhere seen to overlie the Waitaki Stone, not even in the typical sections at Pareora and Awamoa. At these places, unfortunately, the sections are so obscure that the relationships cannot be determined.

In the Waihao district the Mount Harris beds, assigned by Captain Hutton and the Geological Survey to the Pareora series, rest not upon the Waitaki Stone, which is present everywhere, but upon the Lower Mesozoic basement rocks. The meaning of this is somewhat significant.

The sections at Hampden, Kakanui, Enfield, Wharekuri, Waihao Forks, and Kakanui afford conclusive evidence of the inferior position of beds which are admitted by Captain Hutton to contain the Pareora fauna, and supply a satisfactory solution of the problem at Mount Harris.

The typical Hutchinson Quarry beds are exposed at the old quarry of that name near the Town of Oamaru. Here they form a small isolated patch obscured by a thick deposit of the Oamaru silts. They are intercalated with tuffs, and themselves consist of yellowish-coloured calcareous sands and thin bands of limestone. The Oamaru building-stone is absent in this neighbourhood, and consequently the relationship existing between the Hutchinson Quarry beds and that horizon cannot be determined in the typical locality. Captain Hutton includes the Hutchinson Quarry beds in his Oamaru series, but the Geological Survey assumes that they overlie the Waitaki Stone and belong to a younger series. The underlying beds are not exposed, and the Waitaki Stone is absent, consequently there is nothing to indicate to what horizon the quarry-beds should be referred. Whatever evidence there is tends to show that they belong to the period of volcanic activity which preceded the deposition of the Oamaru Stone, for volcanic activity which commenced in the Oamaru district towards the close of the Waihao greensand period culminated during the deposition of the Hutchinson Quarry beds and ceased before the deposition of the Waitaki Stone. The Hutchinson Quarry beds possess no value for correlative purposes, since their stratigraphical position can only be ascertained by reference to sections elsewhere. The sections north of the mouth of the Kakanui River, Cape Oamaru, and Teschemaker's clearly correlate the Hutchinson Quarry beds with the horizon which underlies the Waitaki Stone. The beds of this horizon have been generally known as the Hutchinson Quarry or Mount Brown beds. In the present classification

I have used the latter name as the more appropriate of the two. The Mount Brown, Mount Donald, Hutchinson Quarry, and Kakanui River beds all belong to the same horizon.

In the Waipara district the Cretaceous, Lower and Younger Tertiaries are very fully developed, richly fossiliferous, and exposed in many magnificent sections which are easily accessible. The district possesses a combination of favourable conditions not found elsewhere, and for this reason it must be regarded as a classic locality of rare geologic importance.

Distinctive Fauna of Oamaru Series.

The fossils which distinguish the three principal horizons of the Oamaru series, as now defined by me, are as follows:—

Waitaki Stone.

Meoma crawfordi, Hutton.
Cirsotrema browni, Zittel.
Pseudamussium huttoni,* Park.
Magellania novara, Jhering.

Mount Brown Beds.

Kekenodon onomata, Hector.
Cassidaria senex, Hutton.
Cirsotrema lyrata, Zittel.
Cirsotrema browni, Zittel.
Pecten hutchinsoni, Hector.
Pecten beethami, Hutton.
Pecten hochstetteri, Zittel.
Pecten fischeri, Zittel.
Pecten polymorphoides, Zittel.
Pecten williamsoni, Zittel.
Amussium zitteli, Hutton.
Pseudamussium huttoni, Park.
Plagiostoma lævigata, Hutton.
Lima palaeta, Hutton.
Magellania parki, Hutton.
Magellania novara, Jhering.
Terebratella gaulteri, Morris.
Terebratella oamarutica, Boehm.
Terebratula tayloriana, Colenso.

* For more than thirty years this beautiful pecten, which is found in the Oamaru series all over New Zealand, has been erroneously known to New Zealand geologists as *Pecten hochstetteri*, Zittel. It is smooth on both valves, and easily distinguished from *P. hochstetteri*, which is smooth on one valve and marked with fine radiating ribs on the other. Mature examples of the latter are about half the size of mature shells of *Pseudamussium huttoni*.

Bouchardia elongata, Hutton.
Bouchardia tapirina, Hutton.
Trochocyathus mantelli, Tenison-Woods.
Sphenotrochus huttonianus, Tenison-Woods.
Cup-shaped *Cellepora*.

Waihao-Kakahu Beds.

Aturia australis, McCoy.
Pleurotoma awamoaensis, Hutton.
Pleurotoma alta, Hutton.
Ancilla hebera, Hutton.
Terebra tristis, Hutton.
Scaphella corrugata, Hutton.
Turritella kanieriensis, Harris.
Turritella cavershamensis, Harris.
Natica darwini, Hutton.
Crepidula incurva, Zittel.
Cirsotrema browni, Zittel.
Dentalium mantelli, Zittel.
Dentalium giganteum, G. B. Sowerby.
Ostrea wullerstorfi, Zittel.
Pseudamussium huttoni, Park.
Amussium zitteli, Hutton.
Limopsis insolita, G. B. Sowerby.
Glycymeris globosa, Hutton.
Cucullæa alta, G. B. Sowerby.
Mactropsis traili, Hutton.

Of these fossils, *Cirsotrema browni* and *Pseudamussium huttoni* range from the Oamaru Stone to the base of the Waihao greensands. *Meoma crawfordi*, which first appears in the Mount Brown horizon, becomes a common form in the Oamaru Stone. *Kekenodon onomata* is characteristic of the Mount Brown beds, but at Ngapara and Marawhenua rises into the Oamaru Stone. *Pecten hutchinsoni*, *P. hochstetteri*, *P. fischeri*, and *Plagiostoma lævigata* appear to be confined to the middle or Kakanui horizon. *Amussium zitteli* is found in the Lower Waihao beds, but is never abundant. *Aturia australis*, which is fairly common in the lower division, appears occasionally in the Mount Brown horizon, but so far as known does not reach into the Waitaki Stone. Of the two fine examples of this nautiloid in the Otago Museum, one is from the Lower Kakanui limestone, and the other from the Wharekuri greensands. *Turritella kanieriensis* is abundant in the beds overlying the coal, while *T. cavershamensis* occasionally reaches into the middle of the Mount Brown beds. *Dentalium mantelli*, *D. giganteum*, *Limopsis insolita*, and *Cucullæa alta* are distinctive of both the Waihao and Mount Brown beds.

Physical Characteristics.

Oamaru Stone.

The typical Oamaru building-stone now being quarried at Deborah, Totara, and Teschemaker's, on the main south railway-line to Dunedin, is a soft pale-grey calcareous rock principally composed of comminuted corals and foraminifera. The quarries all lie east of the railway, along the eastern boundary of the outcrop of the stone—that is, on the side furthest from the old Tertiary shore-line. Passing southwards towards the Kakanui, and westward in the direction of Weston, Enfield, Ngapara, Waitaki Valley, and other places lying along or near the old Miocene shore-line, the Oamaru Stone gradually merges into a yellowish-brown calcareous sandstone containing the scattered remains of large echinoderms, a few brachiopods, *Pseudamussium huttoni*, and *Cirsotrema browni*. Close to the old shore these forms are mingled with examples of the littoral shells which abound in the overlying Mount Brown beds.

Mount Brown Beds.

These beds generally consist of glauconitic sands, often passing into a soft sandstone, or yellowish-brown coralline sands and sandstones, which in places pass into rubbly or impure limestones. In only a few places is there such an excess of carbonate of lime as to warrant the quarrying of the stone for burning into lime.

These beds are easily distinguished from the Waitaki Stone by the presence of a rich and varied fauna. In addition to numerous corals, bryzoans, and broken echinoderm spines, they contain a great assemblage of pectens and brachiopods, many of which appear to be characteristic of this horizon.

At Kakanui the Waitaki Stone is separated from the Mount Brown beds by a considerable thickness of tuffs and basalt. Passing westward the volcanic matter gradually diminishes in thickness, so that at Teschemaker's they are separated by only a few feet. Westward of Weston they are directly in contact with each other, the Mount Brown horizon here consisting of glauconitic sands mixed with tufaceous matter.

It is a noticeable feature, perhaps seen to better advantage in the cliff-escarpments in the Waitaki Valley and Waihao district than elsewhere, that the Mount Brown beds gradually merge into the Waitaki Stone as they approach the old shore-line, forming a single continuous calcareous horizon. Each horizon, however, still preserves its distinctive features, the Waitaki Stone being represented by the band of yellowish-brown calcareous sandstone with *Meoma crawfordi*, &c., and

the Mount Brown beds by glauconitic sands, or a band of glauconitic sandstone a few feet thick adhering to the base of the Waitaki Stone, and crowded in places with brachiopods and numerous fine examples of *Pseudamussium huttoni*, *Cirsotrema browni*, and more rarely *Plagiostoma lævigata*.

The calcareous sandstones at Shag Valley, Waikouaiti, and Brighton contain a varied fauna which correlates them with the Mount Brown rather than the Waitaki Stone horizon. At Waikouaiti North Head* they attain a thickness of over 350 ft., this great expansion of the lower horizon having apparently taken place at the expense of the Oamaru Stone.

At Millburn limestone quarry, south of Lake Waihola, the Mount Brown beds are represented by beds of glauconitic sandstone, which pass upward into a compact limestone† about 80 ft. thick. It is probable that the upper part of this limestone and the calcareous sandstones which overlie it are the local representatives of the Waitaki Stone.

The compact limestone at Millburn is extremely variable in quality along its horizontal extension both going north and south. Passing northward it becomes intercalated with narrow bands of glauconitic sandstone, and attempts to burn the rock for lime at different points have been unsuccessful through the excess of sandy impurity.

Waihao-Kakahu Beds.

These generally consist of blue sandy clays and soft bluish-green sandstones which often contain thin layers, or detached lens-shaped masses, of hard calcareous sandstone. Near the old shore-line these rocks sometimes consist of loose pebbly shell beds, or of loose sandy beds and blue clays alternating.

The molluscous fauna of this horizon is mainly of a littoral character, and it is not a little singular that it contains a number of recent shells that are not often seen in the overlying Mount Brown beds, and never in the Waitaki Stone. This apparent anomaly is doubtless explained by the circumstance that the whole series was deposited on a sinking shore-line, and consequently, while the gradually deepening sea-floor favoured the existence of coralline and brachiopod life, it caused the local extinction or migration of the littoral life.

Where the old coast-line was flat and shelving, the littoral shells would follow the retreating shores westward; but where the coast-line was bounded by high steep land, as we know was the case for long stretches, the littoral forms would be submerged in uncongenial depths, and compelled to migrate

* Park, "On the Geology of North Head, Waikouaiti" (Trans. N.Z. Inst., vol. xxxvi., 1903, p. 421).

† Park, "On the Geology of the Rock Phosphate Deposits of Clarendon, Otago" (Trans. N.Z. Inst., vol. xxxv., 1902, p. 391).

to places where the conditions were more favourable for their existence.

Among the living shells found in this horizon, *Lucina divaricata* has not been identified in either the Kakanui beds or Waitaki Stone. *Rhynchonella nigricans* ranges through the three horizons, while *Ancilla australis*, *Scapella gracilis*, *Siphonalia nodosa*, and *Struthiolaria populosa* are common to both the Waihao and Kakanui horizons, but absent from the Oamaru Stone, as would naturally be expected.

Conditions of Deposition.

The succession of grits and conglomerates, with coal, clays, and sandstones with a littoral marine fauna, followed by coralline sandstones and limestones, clearly prove that the Oamaru series was formed during a period of slow submergence of the old Tertiary shore-line. The grits, and conglomerates, and fire-clays accumulated on the sea-shore and in estuaries, forming the narrow low-lying beach on which the fringe of coal-vegetation afterwards established itself and flourished. The slow progressive sinking of the land in time submerged the forests and destroyed the vegetation, which became covered with littoral sands and estuarine clays, while the littoral deposits in turn became covered by the coralline accumulations of the deeper seas.

The character of the fauna and the large size of the shells indicate warm conditions of a subtropical sea.

Distribution.

After the deposition of the Waitaki Stone the sinking movement ceased, and there began a period of elevation. The newly formed beds now emerged from the sea, arranged as a narrow marginal fringe or bench which contoured around the bays and headlands of the old Tertiary shore-line. They also stretched far back among the mountains, into inland basins and winding fiords, some of which for length and diversity of form are without a parallel at the present time.

Physical Geology.

From the marginal distribution of the Miocene Tertiaries we gather some interesting information with respect to the physical geography of New Zealand in the Eocene. We learn, in the first place, that the main mountain features had already been determined; and, in the second place, that the old Tertiary fiords and inland basins, before the Miocene submergence, were merely deep valleys of erosion which the sinking of the land enabled the sea to encroach and flood like the submerged valleys forming the fiords of south-west Otago in the present day.

The Wharekuri basin had access to the open sea by a narrow channel on the south side of Kurow Hill; the Trelissic basin had its outlet by the Broken River into the estuary of the Waimakariri. In Marlborough there were the famous Clarence and Awatere fiords, long, almost straight, parallel gutters stretching far back between the overhanging Kaikouras. The old outlet of Clarence fiord was in a line with the present course of the valley. But in Pleistocene times, during the great extension of the glaciers, a subsequent stream which entered the sea ten miles south of Shades Creek cut its channel back through the northern end of the Seaward Kaikouras until it tapped the drainage-area of the Clarence River. Having a shorter course, and consequently a greater velocity and erosive power, the subsequent stream in time diverted the Clarence to its own course. The nakedness of the landscape, the sharpness of the outline of mountain and ridge, are such as to stamp the impress of newness upon the features of the country. To the geologist this newness is apparent and not real. It is a mental deception conveyed to the eye mainly through the exaggerated height of the surrounding mountains compared with the width of ridge and valley. But we know that the old floor of these fiords for a distance of over forty miles is occupied by Miocene Tertiaries, and therefore we are unable to escape from the conclusion that the valleys they occupy were carved prior to the Miocene.

Proceeding to Nelson we find that the same conditions prevailed. The Tertiaries ramify the old fiord-valleys of the Motueka and its tributaries the Tadmor, Wangapeka, and Baton; of the Takaka and Aorere.

On the west coast of Nelson the marine beds follow and contour around the Inangahua and Buller Valleys and their branches. The ramifications of the old Buller fiord were of greater extent than those of any fiord existing at the present time. A long arm extended up to the foot of Mount Owen, throwing off a lateral branch which reached eastward nearly to the Mount Hope. Another stretched south-east to the base of the main divide, opening out into a great inland basin, now known as the Maruia Plains.

The Tertiary bench formed an encircling fringe around the whole of the South Island. After its emergence from the sea it became carved and eroded before the Pliocene submergence, during which the Greta and Wanganui beds were deposited.

The next great uplifting of the land took place near the close of the Pliocene, and the upward movement continued until the elevation was such as to permit the accumulation of great masses of glacier-ice among the higher mountain-chains. This was in the Pleistocene—that is, the glacier

period of New Zealand was contemporary with the glacial period of northern continental Europe.

Of the maximum elevation reached we know nothing. One thing, however, is certain—namely, that as soon as the maximum elevation was reached the sinking of the land at once set in. The glaciers now began their retreat to the main divide, and at this time the great Southland, Canterbury, and Moutere* gravel plains were formed on the gradually sinking surface of the land. Thus we find that New Zealand since the close of the Secondary period has been rising and sinking with singular regularity.

The South Island of New Zealand at the close of Eocene consisted of a long narrow mountain-chain with many descending ridges and outlying rocky islets. The watershed was so narrow that no large streams existed, while the sinking of the land lessened the height of the dry land and correspondingly decreased the velocity of the descending meteoric waters. Torrential streams were absent, and denudation of the land was comparatively slow. The Tertiary deposits were laid down on the floor of the open sea, and in all the bays, deep indentations, and long fiords existing at the time; and everywhere the same conditions of quiet deposition appear to have existed.

The uniformity of the contained fauna is not less remarkable than the uniformity of the sediments. Some localities yield forms that are specially distinctive of the place, but it is notorious that the characteristic fossils of each horizon are the same from one end of New Zealand to the other.

In the majority of places near the coast the Tertiary beds are lying flat, or are only slightly inclined, except where faulted, or disturbed by igneous intrusions. In the neighbourhood of Lake Wakatipu, and along the flanks of the Kaikouras in Marlborough, they are nipped up and entangled among the older rocks by extensive faulting. But the involvement is not great, and, in the case of the Kaikouras, of no structural or tectonic importance, as is clearly shown where the sections are drawn to natural scale.

Manifestly the main orographical features of the country were determined after the close of the Jurassic period—a view which receives support from the distribution of the Waipara series, which was apparently deposited as a marginal beach on

* The Moutere gravels, which rise from sea-level at Golden Bay to a height of over 2,000 ft. at the Hope Saddle, were formed by the Motueka at the time that river drained the north-west slopes of the St. Arnaud and Spencer Mountains. The Buller River by its rapid recession intercepted the head-waters of the Motueka, which is now greatly diminished in volume.

the old Cretaceous shore-line, like the Oamaru series at a later date. Moreover, it occurs in the Trelissic basin and in the Clarence and Awatere Valleys, which must therefore have existed as arms of the sea prior to its deposition.

BASEMENT ROCKS.

In the Waipara district, and in several parts of Marlborough, and in the country between Onekakara, near Hampden, and the Upper Kakanui, the Oamaru series rests on the Waipara formation; elsewhere it lies directly on the older Mesozoic or Palæozoic basement rocks. Thus in the Province of Otago it rests principally upon mica-schist and altered sedimentaries; in Canterbury, upon Lower Mesozoic claystones and sandstones; and in Nelson and Westland, mainly upon schists, quartzites, slates, and other altered sedimentary rocks.

INFLUENCE OF BASEMENT ROCKS.

In the places where the Oamaru series rests upon the older basement rocks its lowest member consists of grits and conglomerates, derived from the erosion of the adjacent country. Coal, too, generally occurs with these rocks—at any rate near the old shore-line; but in the localities where the series rests upon the members of the Waipara formation the grits, conglomerates, and coal are absent. The absence of the grits and conglomerates is doubtless due to the lack of the requisite hard rock in the Waipara series to supply the materials, but the absence of the coal is the result of causes which are not very obvious.

EFFECTS OF DIFFERENTIAL ELEVATION.

For the most part, the Oamaru series forms the maritime hills and downs of Otago and Canterbury, and a great part of Marlborough, Nelson, and Westland. It gradually ascends as it proceeds inland, in many places rising to an elevation of between 2,000 ft. and 3,000 ft. in the inland basins and valleys and on the flanks of the foothill ranges. And this feature is not confined to the East Coast alone—it is equally true of the western portion of the Province of Nelson, and of Westland, as the examples given hereafter will show.

In North Otago the Waitaki Stone and its associated rocks ascend the Waitaki Valley a distance of over fifty miles from the sea, ending in the Wharekuri basin, which is only a few square miles in extent, being bounded on all sides by steep mountains. Here the Tertiary beds reach a height of over 2,300 ft. above sea-level.

In the Trelissic basin the Oamaru series rises to a height of 3,200 ft. This basin is somewhat less than four miles square, and surrounded on all sides by steep mountains.

In the Waipara district the same beds form ridges reaching over 1,800 ft. high at their highest parts.

The old Tertiaries at the lower end of the Takaka Valley occur at sea-level, but they rise with the gradient of the valley, and gradually ascend till in a distance of thirty miles they reach Mount Arthur Tableland, 3,600 ft. above the sea, where they are almost horizontal. From the tableland going southward the same beds cling to the western flanks of the main range at elevations varying from 2,000 ft. to 3,000 ft., descending westward towards the sea at Mokihinui and Westport and intermediate places. This mantling fringe of Middle Tertiary marine rocks ascending from sea-level on both coasts affords a measure of the elevation of the land since the beginning of the Pliocene, and, moreover, clearly proves the differential rate of the upward movement.

The greatest elevation has in all cases taken place along the main orographical axis of the Island, which is situated closer to the west coast than the east. The differential land-movement being most acute on the west coast introduced unequal stresses, which resulted in extensive faulting of the coal-measures between the sea and the axis of greatest elevation. A notable example of this faulting occurs in the Aorere Valley near Collingwood. On the south side of the river the Tertiaries lie at sea-level, but on the north side they crown the range at an elevation of 1,000 ft., and dip away to the west coast.

Contemporary Volcanic Eruptions.

While the sediments of the Tertiary fringe were accumulating on the littoral of the Miocene seas, volcanic eruptions commenced in the area lying between Moeraki and Oamaru. They were submarine, and took place at points lying some miles to the seaward of the old shore-line, most notably in the areas now known as Ngapara, Waiareka, Oamaru, and Kakanui. These eruptions were not very violent; and it was only at Kakanui, and perhaps at Oamaru, that the ejected materials were piled up so as to form volcanic islands. So far as can be ascertained from the distribution of the matter, the volcanic activity began after the close of the Waihao-Kakahu horizon, and ended before the deposition of the Waitaki Stone began. The main outbursts were apparently confined to the Mount Brown or Hutchinson Quarry period.

There is reason to believe that the volcanic eruptions in the Hauraki Gulf area which produced the tuffs interbedded with the Waitematas were contemporary with those near Oamaru.

Life of Oamaru Series.

At the time of the deposition of the sediments of this formation there lived in the New Zealand seas a zeuglo-

don whale (*Kekenodon onomata*, Hector), a giant penguin (*Palæudyptes antarcticus*, Huxley), a huge shark (*Carcharodon auriculatus*, Blainville), a ray (*Myliobatis plicatilis*, Davis), as well as a large nautilus (*Aturia australis*, McCoy). In the deeper waters there flourished a great variety of corals, bryzoans, and *Foraminifera*, and with these many brachiopods, pectens, and echinoderms. In the shallow water and estuaries there lived a great assemblage of molluscs, many of which were remarkable for their large size.

Among the shells, which grew to a great size in these genial Tertiary seas, were the following:—

Ostrea wullerstorfi, Zittel.
Pecten athleta, Zittel.
Pecten beethami, Hutton.
Pecten hutchinsoni, Hutton.
Pseudamussium huttoni, Park.
Plagiostoma lævigata, Hutton.
Cucullæa ponderosa, Hutton.
Cucullæa alta, Hutton.
Crassatellites ampla, Zittel.
Dosinia magna, Hutton.
Cardium patulum, Hutton.
Dentalium giganteum, Hutton.
Pleurotoma hamiltoni, Hutton.
Pleurotomaria tertiaria, McCoy.
Cirsotrema lyrata, Zittel.
Turritella cavershamensis, Harris.
Natica darwini, Hutton.

AGE OF OAMARU SERIES.

This formation is ascribed by Captain Hutton* to the Oligocene period, principally, he says, from the occurrence in it of the Cretaceous genus *Holaster*, two species of which he has described from the Cobden limestone, near Greymouth.† The genus *Holaster*, although Cretaceous, ranges into the Miocene of Europe. Of the remaining genera of *Echinodermata* recorded by Captain Hutton from the Oamaru series in his catalogue of the Tertiary *Mollusca* and *Echinodermata*, all but one or two are represented by living species. According to Zittel all of these genera are Tertiary and Recent with the exception of the genus *Cidaris*, which ranges from Permian to Recent.

* Hutton, "The Geological History of New Zealand" (Trans. N.Z. Inst., vol. xxxii., 1899, p. 170).

† Hutton, "On some Fossils lately obtained from the Cobden Limestone at Greymouth" (Trans. N.Z. Inst., vol. xx., 1887, p. 268).

The Pareora series of Captain Hutton contains from 20 to 65 per cent. of living molluscs. The Waihao and Kakahu greensands, and the Hampden clays, according to that writer, contain the same fauna as his Pareora series, which he regards as Miocene.*

Sir James Hector and Mr. McKay have always maintained, and, I think, rightly, that these beds underlie the Waitaki Stone, so that, even disregarding the position of the typical Pareora for the moment, we are compelled to admit that a Miocene fauna exists below the Waitaki Stone. For this reason I think that the Oamaru series must be referred to the Miocene period, having regard for the large proportion of living species which it contains.

In Europe, where the Tertiary record is complete, it is easy to divide the scale of time into small units each characterized by some peculiar feature of its fauna or flora; but in New Zealand, where the Eocene is absent, and where the oldest Tertiaries contain a purely local fauna of which from 20 to 30 per cent. are still living, it is not possible to refer the beds with any degree of accuracy to the finer divisions recognised in the Northern Hemisphere.

Relations of Oamaru Series to Lower Tertiary Beds in the North Island.

I will deal first with the marine Tertiaries in the Waitemata district of Auckland.

The pectens which distinguish the Mount Brown or Hutchinson Quarry horizon of the Oamaru series are also characteristic of the middle division of the Waitemata beds near Auckland, which yielded a number of the types originally described by Zittel.

Among the forms common to the middle division of the Oamaru formation and the Waitemata beds are *Pecten fischeri*, *P. vellicatus*, *P. polymorphoides*, *P. williamsoni*, *Pseudamussium huttoni*, and *Amussium zitteli*. A large number of the corals, bryzoans, and *Foraminifera* found in the Orakei Bay beds are also present in the lower limestone at Kakanui and Teschemaker's, commonly associated with the pectens enumerated above. On the other hand, the brachiopods, which are so plentiful at Kakanui, Hutchinson Quarry, Waitaki Valley, Mount Brown, and some parts of Mount Donald, are practically absent from the Waitematas. This, however, can hardly be regarded as surprising in places so widely separated. Even in the Oamaru and Waipara districts the brachiopods are by no means evenly distributed in the same bed, but mostly occur in colonies, often comprising a vast number of individuals.

* *Loc. cit.*, p. 171.

This partial distribution in horizontal extension is well seen in the long line of horizontal limestone escarpment on the south side of the Waitaki Valley between Black Point and the Marawhenua, and also along the limestone crests of Mount Donald and Mount Brown, in the Waipara district.

The palæontological evidence seems to be sufficiently strong to connect the middle horizon of the Oamaru series, comprising the Kakanui, Hutchinson Quarry, and Mount Donald beds, with the Orakei Bay beds of the Waitematas of Auckland.

The basement beds or lower division of the Waitematas, as exposed at Cape Rodney, Kawau Island, Motutapu Island, and Papakura, contain a molluscous fauna which includes many of the characteristic fossils of the Waihao horizon of the Oamaru series. They contain, for example, such characteristic forms as *Ostrea wullerstorfi*, *Pecten burnetti*, *P. beethami*, *Crassatellites ampla*, *Pseudamussium huttoni*, *Rhynchonella nigricans*, and should, I think, be correlated with the Waihao horizon.

The equivalent of the Waitaki Stone is absent in the Waitemata area, but a calcareous sandstone or limestone makes its appearance further south in the Lower Waikato, Aotea, Raglan, Pirongia, Waipa, Kawhia, Upper and Lower Mokau, where it contains *Meoma crawfordi*, *Cirsotrema browni*, *Pseudamussium huttoni*, and *Magellania novara*, all characteristic of the Oamaru Stone horizon.

The sandstones lying conformably below the Waipa limestone, resting on the coal-measures, contain *Cirsotrema browni*, *Calyptræa calyptræformis*, *Cassidaria senex*, *Pseudamussium huttoni*, *Pecten fischeri*, *Cucullæa alta*, *Lucina divaricata*, and *Dentalium lævis*, all of which are found in the Waihao beds above the coal.

AGE OF WAIPARA SERIES.

Sir Julius von Haast* states that he found the impressions of dicotyledonous plants, including *Fagus ninnissiana*, *Phyllites eucalyptroides*, *Loranthophyllum dubium*, *Griselina mytifolia*, in the lowest part of this series at Waipara and Malvern Hills.

If these species, and the relations of the plant beds to the saurian beds, have been accurately determined, we have a condition of things resembling that of the Laramie (lignitic) series of the Rocky Mountains in the United States, which is referred by American geologists to the Upper Cretaceous.

* Haast, "Geology of Canterbury and Westland," Christchurch, 1879, p. 291.

Hampden Beach Beds.

Stratigraphy.

In the sea-cliffs opposite the Township of Hampden the beds consist of sandy clays, in the upper part of which there occur a few layers of hard calcareous masses. The strata dip N.N.E., and proceeding along the beach towards Kakanui the higher beds exposed in the sea-cliffs are more sandy and become fossiliferous. They are seen to pass under the Waiareka tuffs, as described by Sir James Hector* and Mr. McKay.†

Fossils.

A collection of fossils from these beds included the following forms:—

1. *Aturia australis*, McCoy.
2. *Siphonalia nodosa*, Martyn.
3. *Ancilla australis*, Sowerby.
4. *Ancilla hebera*, Hutton.
5. *Scaphella pacifica*, Lamarck.
6. *Scaphella corrugata*, Hutton.
7. *Pleurotoma fusiformis*, Hutton.
8. *Natica zelandica*, Quoy and Gaimard.
9. *Natica darwini*, Hutton.
10. *Struthiolaria papulosa*, Martyn.
11. *Calyptræa calyptræformis*, Lamarck.
12. *Crepidula monoxyla*, Lesson.
13. *Turritella kanieriensis*, Harris.
14. *Lotorium spengleri*, Chemnitz.
15. *Cirsotrema browni*, Zittel.
16. *Dentalium mantelli*, Zittel.
17. *Chione stutchburyi*, Gray.
18. *Glycimeris globosa*, Hutton.
19. *Limopsis insolita*, Sowerby.
20. *Cucullæa alta*, Sowerby.
21. *Pecten hutchinsoni*, Hutton.
22. *Pseudamussium huttoni*, Park.
23. *Ostrea angasi*, Sowerby.
24. *Trochocyathus mantelli*, M. Edw. and H.
25. *Notocyathus pedicellatus*, Tenison-Woods.
26. *Flabellum radians*, Tenison-Woods.

Of the twenty-four molluscs in this collection, ten, or 41·5 per cent., are still living. Captain Hutton,‡ in his paper "On the Geology of the Country between Oamaru and Moeraki," gives a list of thirty-five molluscs reported from

* Hector, Repts. of Geol. Expls., 1883–84, p. xxiv., and 1886–87, p. xx.

† McKay, Repts. of Geol. Expls., 1883–84, p. 61., and 1886–87, p. 6.

‡ Hutton, Trans. N.Z. Inst., vol. xix., 1886, pp. 246–47.

the Hampden clays, of which seventeen, or 48·6 per cent., are living forms.

Captain Hutton's list contains the following fossils not found by me:—

1. *Scaphella australis*, Quoy and Gaimard.
2. *Siphonalia nodosa*, var. *conoidea*, Hutton.
3. *Cominella*, sp. ind.
4. *Nassa tatei*, Tenison-Woods.
5. *Pleurotoma buchanani*, Hutton.
6. *Natica suturalis*, Hutton.
7. *Cerithium cancellatum*, Hutton.
8. *Turritella rosea*, Quoy and Gaimard.
9. *Trochus* (?) sp. ind.
10. *Meretrix multistriata*, Sowerby.
11. *Trigonia pectinata* (?), Lamarck.
12. *Solenella funiculata*, Hutton.
13. *Mytilus magellanicus*, Lamarck.
14. *Entalophora zealandica*, Mantell.

Of the thirteen molluscs in this list, five, or 38·5 per cent., are still living.

KAKANUI VALLEY, NEAR MAHENO.

Behind Clark's mills, on the north side of the Kakanui Valley, nearly opposite Maheno Railway-station, which is about a mile away, there is a long line of steep escarpment crowned by the Oamaru Stone. The beds forming this cliff extend northward to Teschemaker's, and eastward—that is, down the valley—about a mile. The most complete section is exposed about 6 chains below Clark's mills, where the Waiareka tuffs, forming the base of the cliff, are followed by a horizon consisting of grey clays interbedded with coralline limestone, which is in turn overlain by calcareous sandstones intercalated with two sheets or sills of olivine-basalt.

The tuffs contain a few indistinct fossils, and bed No. 7 several minute bivalves and numerous *Foraminifera*. Beds Nos. 9 and 11, and possibly No. 6, represent the Oamaru Stone proper. The presence of the basalt sill shows that volcanic activity was nearly contemporary with the deposition of the lower part of the Oamaru Stone in the Kakanui area. Elsewhere, both to the north and south, activity appears to have ceased somewhat earlier.

At Clark's mill the Oamaru Stone is interbedded with a bed of clay with white chalky joints. This bed varies from a thickness of 12 ft. behind the mill to a few inches at Teschemaker's, less than a mile distant. West of the latter place it thins out altogether. The basalt sill as seen in the longitudinal section of the escarpment, about 2 chains nearer

the mill than the cross-section shown in fig. 1, has been intruded partly along the plane of the clay-bed. The sill ends

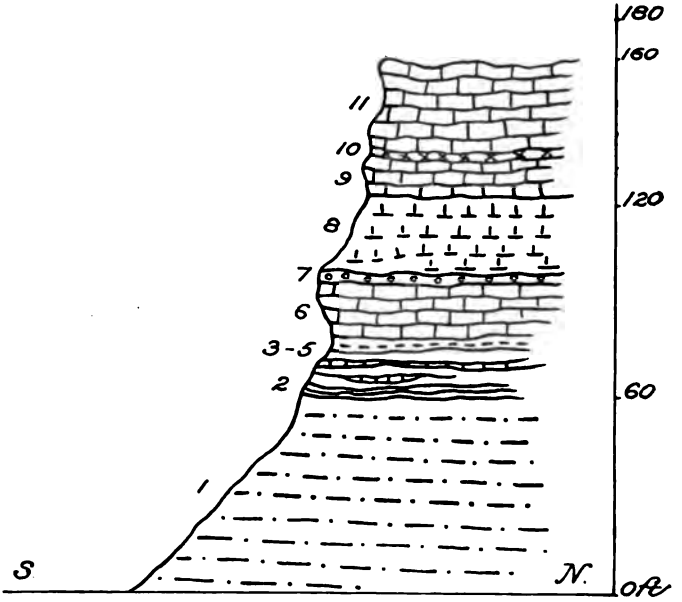


Fig 1.

SECTION NEAR CLARK'S MILLS, MAHENO.

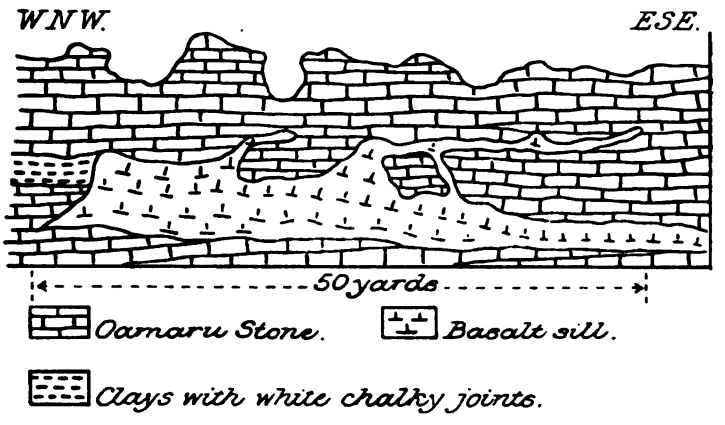
1. Dark-green tuffs, Waiareka tuffs, 60 ft. 2. Gritty sandstone, 4 ft. 3 in. 3–5. Grey clays intercalated with layers of coralline limestone, 5 ft. 6 in. to 7 ft. 6. Yellowish-grey calcareous sandstone, 21 ft. 7. Yellowish flaky clays, foraminiferous, 4 in. to 1 ft. 6 in. 8. Sill of olivine basalt, 22 ft. 9. Yellowish-grey calcareous sandstone, 7 ft. to 8 ft. 10. Sill of olivine-basalt, 3 in. 11. Yellowish-grey calcareous sandstone, 25 ft.

abruptly at the westward end. The detached mass of limestone entangled in the basalt tends to show that the calcareous sediments had become partially consolidated before the intrusion of the lava.

SEA-COAST NEAR KAKANUI TOWNSHIP.

From Kakanui Township northward for some distance the beach is bounded by steep cliffs, and in many places is only accessible at low tide. The Tertiaries which form the cliffs bounding the small bay or indentation between the quarry and Trig. T, a quarter of a mile to the north, are lying com-

paratively undisturbed, and contain several horizons crowded with the fossils characteristic of the Oamaru series.



LONGITUDINAL SECTION OF UPPER PART OF CLIFF (4 chains below Clark's Mill, Maheno).

Stratigraphy.

In the sea-cliffs a few chains north of the quarry and lime-kilns there are exposed the Oamaru Stone, and Kakanui or Hutchinson Quarry beds, together with intercalated tuffs and lavas.

The section exposed along the cliff at sea-level, 3 chains north of Kakanui quarry, is shown in fig. 3.

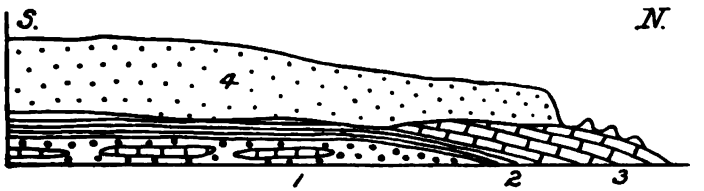


Fig 3.

SECTION ALONG SEA-CLIFF (3 chains north of Kakanui Quarry).

1. Yellow calcareous tuff, fossiliferous. 2. Banded clays and gritty sandstones 3. Calcareous sandstone passing into limestone (Kakanui limestone). 4. Yellow silts.

A few chains further north, the cross-section running from the beach westward to trig. station T is as follows:—

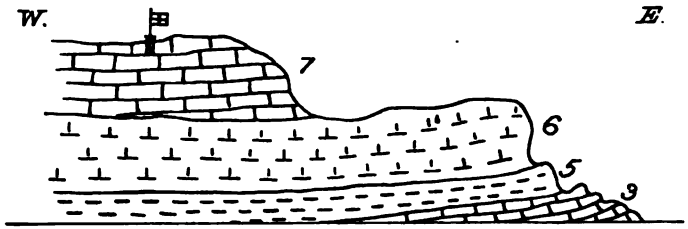


Fig 4.

CROSS-SECTION FROM SEA TO TRIG. T.

3. Calcareous sandstone (Oamaru limestone). 5. Tufaceous greensands, fossiliferous. 6. Basalt flow and tuffs. 7. Calcareous sandstone (Waitaki Stone).

Fossils.

Bed No. 1 consists of hard yellowish-coloured calcareous tuffs, in places passing into an impure limestone. In a large collection of fossils made from it at this place the following species were identified:—

1. *Aturia australis*, McCoy.
2. *Scaphella corrugata*, Hutton.
3. *Siphonalia regularis*, Hutton.
4. *Pleurotoma fusiformis*, Hutton.
5. *Nassa socialis*, Hutton.
6. *Trochus nodosus*, Hutton.
7. *Calliostoma spectabile*, A. Adams.
8. *Dentalium giganteum*, Hutton.
9. *Dentalium mantelli*, Zittel.
10. *Pecten williamsoni*, Zittel.
11. *Pecten hutchinsoni*, Hutton.
12. *Pseudamussium huttoni*, Park.
13. *Venericardia awamoaensis*, Harris.
14. *Lima paleata*, Hutton.
15. *Terebratella gaulteri*, Morris.
16. *Terebratula tayloriana*, Colenso.
17. *Bouchardia tapirina*, Hutton.
18. *Trochocyathus mantelli*, M. Edw. and H.
19. *Balanophyllia hectori*, Tenison-Woods.
20. *Sphenotrochus huttonianus*, Tenison-Woods.
21. *Meoma crawfordi*, (?) Hutton.

Small branching and net corals are very abundant. Crab-remains were also found. A large example of *Aturia australis*,

12 in. in diameter, was discovered on the upper surface of the flat ledge formed by this bed, just within the influence of high tides. On account of the hardness of the rock no attempt was made to extract it.

From bed No. 5, which overlies bed No. 3 of Figs. 3 and 4, and forms the higher part of the Kakanui limestone, I collected the following forms, at a point about 15 chains north of the quarry:—

1. *Kekenodon onomata*, Hector.
2. *Scaphella corrugata*, Hutton.
3. *Siphonalia nodosa*, Martyn.
4. *Cirsotrema browni*, Zittel.
5. *Teredo heaphyi*, Zittel.
6. *Ostrea angasi*, Sowerby.
7. *Anomia alectus*, Grev.
8. *Pecten hutchinsoni*, Hutton.
9. *Pecten burnetti*, Zittel.
10. *Cucullæa alta*, Sowerby.
11. *Lima paleata*, Hutton.
12. *Venericardia awamoaensis*, Harris.
13. *Magellania novara*, Jhering.
14. *Magellania parki*, Hutton.
15. *Terebratella gaulteri*, Morris.
16. *Terebratula oamarutica*, Boehm.
17. *Terebratulina oamarutica*, Boehm.
18. *Meoma crawfordi*, Hutton.
19. *Isis dactyla*, Tenison-Woods.

Cup-shaped *Cellepora*.
Net and branching corals, very abundant.
Crab-remains.

From Kakanui the tuffs extend northward to a point about 90 chains south of Awamoa Creek. On the beach at White Rocks Road they are about 60 ft. thick, and dip east at angles varying from 30° to 35°. At this place they contain a few fossils, among which I collected *Diplodonta zelandica*, Gray, *Tellina angulata*, Hutton, some fragments of an oyster, and broken corals.

AWAMOA CREEK.

The Awamoa beds are regarded by the Geological Survey and Captain Hutton as typically representative of the Pareora beds of Canterbury. They are exposed on the beach at the mouth of Awamoa Stream, and on the banks of the stream in the immediate vicinity. The rocks forming these beds consist of bluish-green sandstones alternating with blue sandy clays. In the clays there are thin beds or bands of hard shelly sandstone, generally pebbly and gritty.

Fossils are very scarce in the bluish-green sandstone, in places quite common in the clays, and very abundant in the hard pebbly bands, which vary from a few inches to about 2 ft. thick. At the time of my visit the beach outcrops were sufficiently free from shingle to enable me to ascertain that the fossiliferous horizon was only a few yards wide, the bulk of the fossils being contained in one narrow band of shelly sandstone.

Stratigraphy.

The beds are so obscured by beach shingle and recent alluvium that nothing whatever can be made of their stratigraphical relations to the Oamaru Stone and tuffs in the neighbourhood. This information is, however, supplied by the section of Tertiaries exposed at the rifle-butts north of Cape Wanbrow.

Fossils.

A small collection of fossils from the Awamoa beds contained the following species:—

1. *Pleurotoma fusiformis*, Hutton.
2. *Pleurotoma buchanani*, Hutton.
3. *Pleurotoma traili*, Hutton.
4. *Lotorium spengleri*, Chemnitz.
5. *Siphonalia nodosa*, Martyn.
6. *Ancilla australis*, G. B. Sowerby.
7. *Ancilla hebera*, Hutton.
8. *Scaphella corrugata*, Hutton.
9. *Scaphella gracilis*, Swainson.
10. *Natica darwini*, Hutton.
11. *Cirsotrema browni*, Zittel.
12. *Struthiolaria papulosa*, Martyn.
13. *Calyptræa calyptræformis*, Lamarck.
14. *Crepidula monoxyla*, Lesson.
15. *Crepidula aculeata*, Gmelin.
16. *Turritella kanieriensis*, Harris.
17. *Dentalium mantelli*, Zittel.
18. *Dentalium lævis*, Hutton.
19. *Chione vellicata*, Hutton.
20. *Limopsis insolita*, Sowerby.
21. *Venericardia awamoaensis*, Harris.
22. *Dosinia greyi*, Zittel.
23. *Glycimeris globosa*, Hutton.
24. *Pecten williamsoni*, Zittel.
25. *Pseudamussium huttoni*, Park.
26. *Lima paleata*, Hutton.
27. *Mactropsis traili*, Hutton.
28. *Crassatellites traili*, Hutton.

Of the above twenty-eight species, eight, or 28·5 per cent., are living; and of the twenty extinct forms nine were found by me in the Hampden beds. Eight species have never, so far as I can gather, been found in beds overlying the Waitaki Stone. They are *Ancilla hebera, Cirsotrema browni, Scaphella corrugata, Dentalium mantelli, Limopsis insolita, Pseudamussium huttoni, Pecten williamsoni, Mactropsis traili.* To these should probably be added *Natica darwini* and *Pleurotoma fusiformis.*

CAPE OAMARU.

Proceeding southward from Oamaru Breakwater the sea-cliffs are found to consist of lavas and agglomerates. About 15 chains past the first point, at a shallow indentation where a blind gully descends to the sea, the agglomerates are underlain by a series of bedded ash-beds, greensands, silts, and sandstones, the two former containing bands or beds of impure limestone. The ash-beds and sandstones dip towards the north at an angle of about 25°, and rest upon a flow of basalt which occurs in pillow-form masses along the base of the cliff. The interstices between the masses are filled with calcareous sandstone or impure limestone.

The pillow-form structure of a lava is not often seen, and this is, I believe, the first record of it in New Zealand. An occurrence of this structure, almost identical with that at Cape Oamaru, is exposed on the beach near Ballantrae, in south-west Scotland. It has been described by B. N. Peach and J. Horne, and figured by them in the Memoirs of the Geological Survey of the United Kingdom for 1899.* In this case the interstices between the pillow-form masses are filled with Silurian limestone.

Stratigraphy.

Here we have unmistakable evidence of contemporary volcanic activity. The lava was poured over the floor of the sea, and in cooling assumed a remarkable pillow-form structure resembling a number of large pillows piled one upon the other. The presence of impure limestone and sandy matter filling the spaces between the pillow-form masses, and the rapidly alternating character of the tuffs and fossiliferous beds immediately overlying, present conclusive evidence of the submarine character of the eruptions. The lithological features of the rocks and the fossil contents serve to correlate these beds with the Hutchinson Quarry and Kakanui limestone horizon.

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* "The Silurian Rocks of Scotland," vol. i.; London, 1903.

The arrangement and relationship of the different beds at this place are shown in fig. 5.

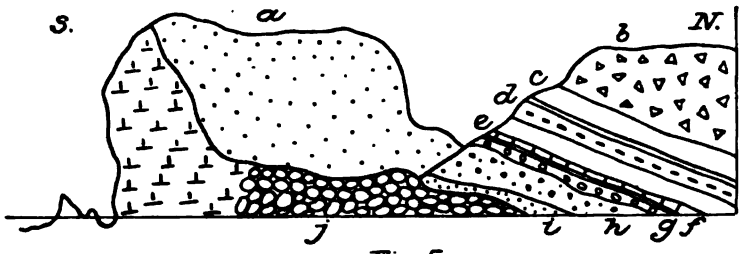

Fig 5

SECTION OF SEA-CLIFF NORTH OF CAPE WANBROW.

a. Yellow Pleistocene silts. *b*. Agglomerates and tuffs. *c*. Bedded tuffs. *d*. Greensands and tuffs, fossiliferous. *e*. Coralline limestone, 3 ft. to 3·5 ft. thick. *f*. Thin-bedded blue clays. *g*. Rubbly calcareous ash-bed, with thin layers of limestone from 2 in. to 6 in. thick near the upper part. *h*. Yellowish-green ash-bed, 18 ft. to 20 ft. thick; fossiliferous. *i*. Sands, silts, and ash, current-bedded; no fossils. *j*. Pillow-form lava and agglomerates.

Fossils.

From bed *d* I collected the following species:—

1. *Pecten hutchinsoni*, Hutton.
2. *Pseudamussium huttoni*, Park.
3. *Magellania novara*, Jhering.
4. *Terebratella gaulteri*, Morris.
5. *Terebratulina oamarutica*, Boehm.

Also numerous corals and *Cidaris* spines.

The same species were also collected from beds *e* and *f*.

From bed *h* I obtained a greater variety of molluscs, including the following forms:—

1. *Ostrea wullerstorfi*, Zittel.
2. *Glycimeris globosa*, Hutton.
3. *Venericardia awamoaensis*, Harris.
4. *Diplodonta zelandica*, Gray.
5. *Pecten hutchinsoni*, Hutton.
6. *Pecten williamsoni*, Zittel.
7. *Pseudamussium huttoni*, Park.
8. *Limopsis insolita*, G. B. Sowerby.

Also cup-shaped bryozoans and corals.

Proceeding southward from the point formed by the pillow-form lava and agglomerates, the latter are seen to be underlaid by thin-bedded tuffs dipping northward at angles varying from 15° to 17°. At the base of these tuffs there is a band of rubbly coralline limestone from 8 in. to 12 in. thick, containing angular fragments of basalt up to 8 in. in diameter.

Still passing southward, the coralline bed is underlain by a great thickness of stratified tuffs, which are current-bedded in places, and continue to dip north until a point 2½ chains from Cape Wanbrow Creek is reached, where they turn over, and thence onward dip to the south, as shown in fig. 6.

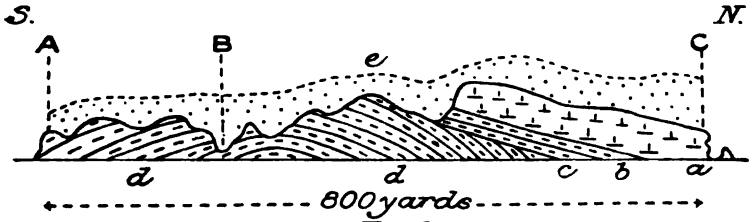

Fig 6.

SECTION OF SEA-CLIFF FROM CAPE WANBROW NORTHWARD.

A. Cape Wanbrow. B. Wanbrow Creek. C. South end of section shown in fig. 5. *a*. Pillow-form basalt and agglomerates. *b*. Thin-bedded tuffs; angle of dip, 15° to 17°. *c*. Band of impure limestone. *d*. Stratified tuffs. *e*. Oamaru silts.

At the north end of the first small bay south of Cape Wanbrow there is a fault where the dip suddenly changes to the north-east; but some 13 chains south of the fault the tuffs resume the southerly dip, which is continued till the rifle-butts are reached, where they are followed by the Oamaru building-stone, fossiliferous tuffs, Hutchinson Quarry, and Awamoa beds.

The section from Cape Wanbrow southward to the termination of the sea-cliffs is shown in the following section:—

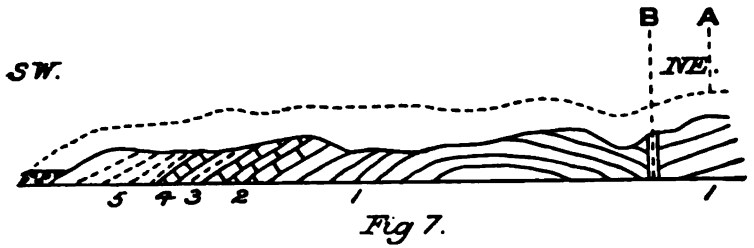

Fig 7.

SECTION ALONG SEA-COAST FROM CAPE WANBROW SOUTHWARD TO RIFLE-BUTTS.

A. Cape Wanbrow. B. Fault; strike nearly N.-S. 1. Tuffs. 2. Oamaru building-stone. 3. Fossiliferous-tuff bed. 4. Hutchinson Quarry beds. 5. Awamoa beds.

The section exposed along the sea-cliff from a point about 4 chains north of the rifle-butts to the first headland is re-

markably clear, and of great importance, as it shows the relations of the Oamaru Stone to the Oamaru or Waiareka tuffs and to the Hutchinson Quarry beds. It is as follows:—

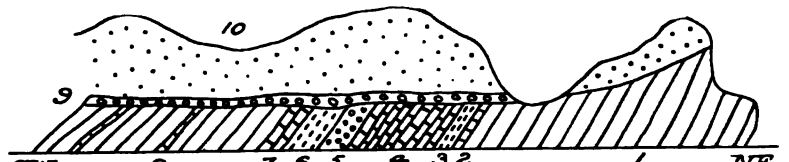

Fig 8.

SECTION OF SEA-CLIFF NORTH OF RIFLE-BUTTS.

1. Tuffs. 2. Bed of coralline limestone, 6 ft. 3. Greenish-blue sandstone, 9 ft. 4. Coralline limestone (Oamaru building-stone), 80 ft. 5. Yellowish-green fossiliferous-tuff bed, 12 ft. 6. Hutchinson Quarry beds, consisting of hard rubbly limestone, 7 ft., overlain by greensands, 11 ft. thick. 7. Impure shelly limestone, 3 ft. thick, crowded with *Turritella cavershamensis*. 8. Fine bluish-green sandstones weathering brown, exposed on beach for a distance of 50 yards. 9. Raised beach, 5 ft. or 6 ft. above high water of spring tides, consisting of beach-shingle mixed with littoral shells all belonging to living species. The most common forms are *Mactra discors*, *Chione oblonga*, *Dosinia australis*, *Atactodea subtriangulata*, *Mytilus edulis*, *Trochus tiaratus*, &c.

The beds strike N.W.–S.E., and dip S.W. at angles varying from 32° to 35°. The dip of the beds as shown in fig. 8 is somewhat exaggerated, in order to crowd the strata into the width of the page.

In this section the Awamoa and Hutchinson Quarry beds are seen to be part and parcel of the same series, a contention urged on several occasions by Mr. McKay, and now admitted by Captain Hutton.

Both Captain Hutton and Mr. McKay correctly enough place the Hutchinson Quarry beds above the Oamaru building-stone, but the former, failing to recognise the existence of two limestones in North Otago, and believing the Oamaru Stone to be the closing member of the Oamaru series instead of the lower of the two limestones, ascribes the Hutchinson Quarry beds to a period subsequent to the Oamaru series.

From bed No. 8, which I believe to be the equivalent of the Awamoa beds, I collected the following forms:—

1. *Scaphella corrugata*, Hutton.
2. *Struthiolaria papulosa*, Martyn.
3. *Turritella cavershamensis*, Harris.
4. *Turritella rosea*, Quoy and Gaimard.
5. *Turritella kanieriensis*, Harris.
6. *Teredo heaphyi*, Zittel.

7. *Crassatellites ampla*, Zittel.
8. *Ostrea angasi*, Sowerby.
9. *Mytilus magellanicus*, Chemnitz.
10. *Corbula caniculata*, Hutton.
11. *Chione vellicata*, Hutton.
12. *Zenatia acinaces*, Quoy and Gaimard.
13. *Psammobia lineolata*, Gray.
14. *Cucullæa alta*, Sowerby.
15. *Solenella australis*, Zittel.

The shelly limestone, bed No. 7, underlying the Awamoa sandstones, contains large numbers of *Turritella cavershamensis*, as well as examples of *Scaphella pacifica*, *Lima paleata*, *Ostrea angasi*, and *Flabellum radians*.

From the greensands, bed No. 6, which evidently represent the Hutchinson quarry horizon, I collected from the lower part especially *Magellania novara*, *Magellania parki*, and *Bouchardia elongata*.

The yellowish-green tuff bed contains a number of small shells, including representatives of the genera *Diplodonta*, *Venericardia*, &c., mostly too minute for identification. Possibly the majority of them are new species.

The Oamaru building-stone is represented by two beds—namely, beds Nos. 2 and 4—which are separated by a thin stratum of dark bluish-green sandstone. These beds are composed principally of comminuted corals and *Foraminifera*, but the higher part of the upper band contains, besides these, a good many littoral shells, among which I collected the following:—

1. *Pecten hutchinsoni*, Hutton.
2. *Pecten williamsoni*, Zittel.
3. *Ostrea angasi*, Sowerby.
4. *Rhynchonella*, sp. nov.
5. *Graphularia*, sp. (?).
6. *Meoma crawfordi*, Hutton.

The higher part of the upper band also contains fragments of volcanic ash. The lower band is quite free from volcanic matter and from large shells, and, being of even texture and colour, furnishes the highest quality of building-stone quarried near Oamaru. The upper band is not so uniform in texture, is variable in colour, often containing streaks of a deep-yellow colour, and is in consequence regarded as of inferior quality.

TESCHEMAKER'S.

There are two bands of limestone at this place, separated by a few feet of fossiliferous tuff. They are well exposed in the old quarry near the crown of the hill overlooking the railway-line. The upper limestone is the typical clean pale

yellowish-grey building-stone. The lower is glauconitic, and largely composed of comminuted corals and *Foraminifera*.

The tuffs are often pebbly, and generally crowded with corals and molluscs. Of the latter I collected the following forms:—

1. *Ostrea wullerstorfi*, Zittel.
2. *Pecten hutchinsoni*, Hutton.
3. *Pecten hochstetteri*, Zittel.
4. *Pecten burnetti*, Zittel.
5. *Pecten williamsoni*, Zittel.
6. *Pseudamussium huttoni*, Park.
7. *Amussium zitteli*, Hutton.
8. *Terebratella gaulteri*, Morris.

Devil's Bridge.

This place is situated near the source of the Oamaru Stream. Here the Waitaki Stone overlies glauconitic sandstones containing fossils in great abundance, and generally well preserved. In the collection from the sandstone the following were identified:—

1. *Calyptræa calyptræformis*, Lamarck.
2. *Teredo heaphyi*, Zittel.
3. *Dentalium mantelli*, Zittel.
4. *Dosinia greyi*, Zittel.
5. *Chione vellicata*, Hutton.
6. *Chione crassa*, Quoy and Gaimard.
7. *Meretrix acuminata*, Hutton.
8. *Venericardia awamoaensis*, Harris.
9. *Lima paleata*, Hutton.
10. *Pecten williamsoni*, Zittel.
11. *Pseudamussium huttoni*, Park.
12. *Ostrea angasi* (?), Sowerby.
13. *Limopsis aurita*, Brocchi.
14. *Cucullæa alta*, G. B. Sowerby.

Pukeuri.

This place lies north of Oamaru, from which it is distant about six miles by rail. The hills facing the railway-line, near Pukeuri, are composed of soft sandstones, which are fossiliferous, and often contain large calcareous nodules. From these beds I collected the following forms in the deep cutting on the main cart-road into the Waitaki Valley:—

1. *Scaphella corrugata*, Hutton.
2. *Scaphella pacifica*, Lamarck.
3. *Siphonalia nodosa*, Martyn.
4. *Pleurotoma fusiformis*, Hutton.
5. *Terebra tristis*, Hinds.

6. *Natica zelandica*, Quoy and Gaimard.
7. *Turritella rosea*, Quoy and Gaimard.
8. *Turritella kanieriensis*, Harris.
9. *Teredo heaphyi*, Zittel.
10. *Ancilla australis*, Sowerby.
11. *Dentalium mantelli*, Zittel.
12. *Pecten williamsoni*, Zittel.
13. *Pseudamussium huttoni*, Park.
14. *Lima paleata*, Hutton.
15. *Chione vellicata*, Hutton.
16. *Corbula caniculata*, Hutton.
17. *Mactropsis traili*, Hutton.
18. *Leda fastidiosa*, Adams.

Neither the Waitaki Stone nor the Oamaru Stone is present in the vicinity of this place, and some difficulty would be encountered in tracing the stratigraphical relations of the two horizons, on account of the great depth of superficial deposits resting on the hills. The character of the fossils, however, clearly correlates the sandstones with a horizon below the Oamaru Stone.

HUTCHINSON'S QUARRY, OAMARU.

The beds exposed near Eden Street Bridge are as follows, in ascending order :—

1. Tuffs intercalated with irregular bands of limestone, 6 ft.
2. Dark glauconitic greensands, 7 ft.
3. Yellowish-coloured glauconitic shelly sandstone, from 4 ft. to 6 ft. thick.
4. Dark glauconitic sandstone, about 14 ft. exposed.
5. Oamaru silts and clays.

From beds Nos. 2 and 3 the following species were obtained :—

1. *Ostrea wullerstorfi* (?), Zittel.
2. *Pecten hutchinsoni*, Hutton.
3. *Pecten williamsoni*, Zittel.
4. *Pseudamussium huttoni*, Park.
5. *Magellania novara*, Jhering.
6. *Magellania parki*, Hutton.
7. *Balanus* (sp. ?).
8. *Isis dactyla*, Tenison-Woods.

Corals, net and branching.
Cidaris spines.
Cup-shaped bryozoans.

The fossils and character of the material clearly relate these beds to the fossiliferous tuffs and calcareous beds at Kakanui Beach and Cape Wanbrow.

Black Point, Waitaki Valley.

A narrow bench of the Tertiary series runs parallel with the Waitaki Railway from near Black Point to Otekaike, a distance of some twelve miles. It rests upon the metamorphic rocks of the Kakanui series, and forms a line of bold steep escarpment which presents many fine faces for critical examination. Perhaps the most interesting and important part of this long section is that exposed at the old Black Point Coal-mine, nearly opposite Borton Railway-station, where the basement beds of the Tertiary series are very clearly exposed.

Stratigraphy.

Mr. McKay * examined, and afterwards accurately described, the stratigraphy of this place in 1876. The numbers of the Tertiary series in descending order are as follows :—

1. Waitaki Stone, with 1a adhering to base.
1a. Glauconitic sandstone, fossiliferous.
2. Sandstones, often micaceous and gritty.
3. Rusty-brown sands and sandstone, containing layers of hard calcareous nodules and lens-shaped masses.
4. Fireclays, carbonaceous shales, and brown coal.
5. Quartz and sandstone conglomerates, often limonitic.

The arrangement and relationships of these beds are shown in fig. 9.

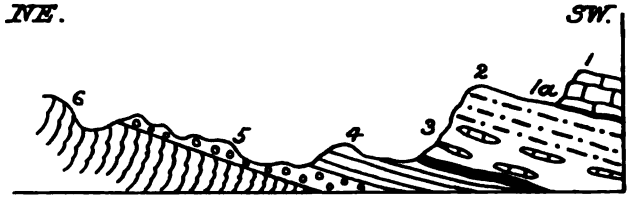

Fig 9.

Section at Black Point Coal-mine.

1. Waitaki Stone. 1a. Glauconitic sandstone. 2. Sandstones, often micaceous. 3. Sandstones, with hard nodules and layers, fossiliferous. 4. Fireclays, shales, and brown coal. 5. Conglomerates, often limonitic. 6. Metamorphic rocks.

Fossils.

The sandstones overlying the coal-shales contain a large number of fossils, of which a considerable collection was made. The fossils in the hard calcareous nodules are gene-

* Reports of Geol. Expls., 1876–77, p. 52.

rally well preserved, but in the sandstone they occur mostly as casts.

Mr. McKay mentions that he made a large collection of fossils here, but does not give a list of the species. In his first report on this place he states that he discovered several genera of Secondary cephalopods, including *Ancyloceras* and *Scaphites*. In his later reports of the Waitaki Valley, in 1876, 1881, and 1882, he makes no mention of these, so it may be assumed that the reported discovery was due to a misidentification of the genera in the early seventies.

The collection made by myself at Black Point Coal-mine included the following species :—

1. *Pleurotoma awamoaensis*, Hutton.
2. *Terebra tristis*, Deshayes.
3. *Ancilla hebera*, Hutton.
4. *Scaphella corrugata*, Hutton.
5. *Siphonalia subreflexa*, Sowerby.
6. *Lotorium spengleri*, Chemnitz.
7. *Struthiolaria papulosa*, Martyn.
8. *Cassidaria senex*, Hutton.
9. *Turritella kanieriensis*, Harris.
10. *Crepidula monoxyla*, Lesson.
11. *Natica zelandica*, Quoy and Gaimard.
12. *Cirsotrema lyrata*, Zittel.
13. *Teredo heaphyi*, Zittel.
14. *Dentalium mantelli*, Zittel.
15. *Ostrea wullerstorfi*, Zittel.
16. *Anomia alectus*, Gray.
17. *Pseudamussium huttoni*, Park.
18. *Cucullæa alta*, G. B. Sowerby.
19. *Glycimeris globosa*, Hutton.
20. *Limopsis insolita*, Sowerby.
21. *Venericardia awamoaensis*, Harris.
22. *Dosinia greyi*, Zittel.
23. *Tapes curta*, Hutton.
24. *Chione vellicata*, Hutton.
25. *Psammobia lineolata*, Gray.
26. *Panopea orbita*, Hutton.
27. *Tellina angulata*, Hutton.
28. *Flabellum radians*, Tenison-Woods.
29. *Balanophyllia hectori*, Tenison-Woods.
30. *Schizaster rotundatus* (?), Zittel.

Crab-remains.

Balanus plates.

Of the twenty-seven species of molluscs enumerated above, six, or 22·2 per cent., are still living; while the majority are common to the Hampden, Kakanui, Awamoa, Waihao Forks, Wharekuri, Kakahu, and Mount Donald beds.

Marawhenua.

From the glauconitic greensands at the base of the Waitaki Stone, a mile and a half east of this place, in the cliffs facing the railway-line, I collected the following forms:—

1. *Kekenodon onomata*, Hector.
2. *Cirsotrema lyrata*, Zittel.
3. *Cassidaria senex*, Hutton.
4. *Teredo heaphyi*, Zittel.
5. *Plagiostoma lævigata*, Hutton.
6. *Lima palæta*, Hutton.
7. *Pseudamussium huttoni*, Park.
8. *Terebratella gaulteri*, Morris.
9. *Terebratella furculifera*, Tate.
10. *Terebratula oamarutica*, Boehm.
11. *Bouchardia tapirina*, Hutton.

Graphularia (15 in. long).
Balanus.
Corals.

The fine pecten *Pseudamussium huttoni* occurs in great numbers, in a fine state of preservation, and easily extracted. The brachiopods occur in thousands. The fossils and stratigraphy clearly correlate these beds with the Mount Brown and Kakanui limestones.

Wharekuri Basin.

Stratigraphy.

There are five well-marked fossiliferous horizons in this basin, which enable the Tertiaries there to be subdivided as follows:—

Waitaki Stone ..	1. Calcareous sandstone.
Mount Brown beds	2. Soft calcareous sandstone and shelly sands, often glauconitic, with *Kekenodon*. 3. Greensand, calcareous, often dark-green, with *Aturia*, &c.
Waihao beds ..	4. Bluish-green and grey sandstones and sandy clays. 5. Quartzose grits and brown coal.

There is no limestone in Wharekuri basin corresponding to the Oamaru building-stone proper. Beds 1 and 2 correspond closely in their fossil contents with the fossiliferous calcareous horizons below the Waitaki Stone at Kakanui. Bed 2 underlies No. 1 conformably, and contains a large number of fossils, many of which are found in bed 1.

Mr. McKay* in 1881 referred bed 1 partly to the Hut-

* Reports Geol. Expls., 1881, pp. 68 and 103.

chinson Quarry beds and partly to the Otekaike limestone, which he regarded, and I think rightly, as distinct from the Ototara (Oamaru) Stone.

Bed 1, the *Kekenodon* beds of Mr. McKay, are shown by him to underlie the Otekaike limestone conformably (section on pp. 68 and 101 of the report). Bed 3, which he calls the Wharekuri greensands, he refers to the same horizon as the Waihao greensands, as I do now; but in a section on page 64 he shows the greensands overlain unconformably by the calcareous sandstone the supposed equivalent of the Otekaike limestone.

I made a careful examination of the line of section referred to, which is obscured with gravels, but was unable to find any evidence in support of Mr. McKay's contention. He admits the obscurity of the section, and, speaking of this supposed unconformity, says, "In the section of these rocks sketched at page 64 the unconformity between *b* and *c* is made perfectly apparent, and is, I believe, exactly as the section would appear provided the obscuring gravels could be cleared away."* Exactly so. The section merely represents his view of what would be seen if the obscuring gravels were cleared away—a view in conformity with the theory of the Geological Survey, which supposes that the Mount Brown beds are of later date than the Waitaki Stone.

As a matter of fact the Tertiary beds in this basin are so much faulted, and the outcrops so obscured by heavy deposits of gravel, that it is impossible for any one to determine what are the relations between the lower greensands and the calcareous shelly sands of the Mount Brown beds. The solution of this problem can, however, be found in the Kakanui and Waipara districts, where the sections are so clear upon this point as to leave no room for theoretical deductions.

The shelly greensands with *Kekenodon* are exposed on the banks of the Waitaki River, half a mile below the junction of the Wharekuri Stream. Here they are lying almost horizontal, and can be traced in that position along the river-bank for half a mile. They also are seen near the top of the foothills running along the south side of the basin, forming conspicuous bluffs and escarpments facing the river-valley. Here the beds also lie horizontal.

We have thus two parallel lines of outcrop, separated by half a mile, one a few feet above the river-level, and the other nearly 400 ft. above the river.

The Wharekuri basin is mountain-girt, and manifestly existed before the deposition of the Tertiaries. The latter have not been folded in the course of tectonic movements, and we

* *Loc. cit.*, p. 73.

can only conclude that the present distribution of the beds at different elevations is the result of extensive faulting.

In the line of section running from the river outcrop to the south side of the basin there is no sign of faulting, nor could such be seen if it existed, on account of the gravels which cover the river-terrace and slopes of the foothills. The section as it actually appears is as shown in fig. 10.

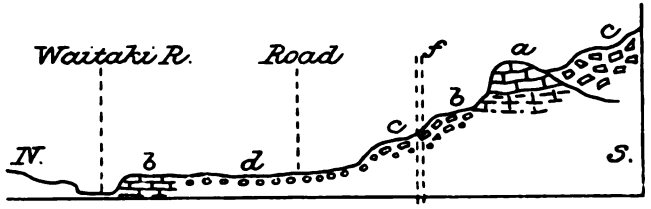

Fig 10.

SECTION FROM WAITAKI SOUTHWARD.

a. Higher part of calcareous sandstone. *b*. Lower part of beds *a*. *c*. Remains of old river-fan. *d*. River-gravels. *f*. Approximate position of great fault.

The Wharekuri Stream cuts back into the foothills parallel with this line of section, some half a mile further north, and in its steep banks at a point about 12 chains above the bridge the beds are seen to be greatly faulted. At this place there is a great vertical fault, and four small faults or dislocations. Mr. McKay does not refer to these faults. They were examined by Mr. Hamilton and the writer in March, 1903, and are shown by Mr. Hamilton* in his paper on some fossils collected in the Wharekuri basin. The sketch made by Mr. Hamilton is shown in fig. 11.

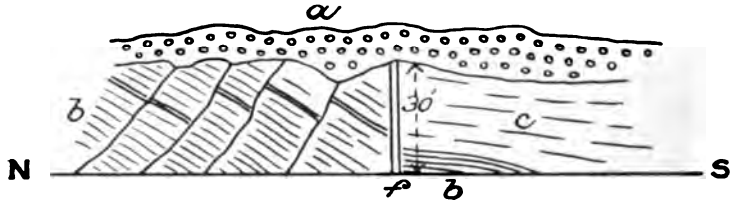

Fig 11.

SECTION ON EAST BANK OF WHAREKURI (12 chains above Bridge).

The actual vertical displacement cannot be measured, but must be considerable, as it has brought the yellowish sand-

* Trans. N.Z. Inst., vol. xxxvi., 1903, p. 463.

stones which overlie the coal opposite the lower greensands. The position the vertical fault would occupy in section from the river-bank southward is indicated in fig. 8.

The seam of brown coal occurs in grey sandstones often yellow on surfaces, and grits, which are exposed in the narrow gorge cut in the foothills by Wharekuri, about half a mile above the bridge. The outcrops of the beds are so obscured by gravels and slope deposits that no stratigraphical relationships can be made out.

Mr. McKay refers the coal-measures to the Pareora series of supposed Miocene age, and in his sketch* of the section, shown by me in fig. 8, he shows the coal-measures and a coal-seam overlying the calcareous sandstone (Otekaike limestone) conformably. I could find no trace of the coal-measures, or of a coal-seam in this section overlying the fossiliferous Tertiaries, and I can only assume that the section figured by him is intended as a graphic representation of his views rather than a statement of the actual facts. Mr. McKay furnishes no evidence in support of a Miocene age for the coal-measures beyond assuming that the coal is associated with the gravels which cover the foothills. Of this latter theory there is no evidence whatever. These gravels are apparently the old high-level gravels formed by the Waitaki River. They can hardly be older than Pleistocene or newer Pliocene.

Sir James Hector, in his Progress Report for 1881, p. xxv., when discussing Mr. McKay's supposed Pareora gravels, says, "These beds, for no better reason than that they are usually found overlying the fossiliferous Pareora beds, have frequently been spoken of as the higher part of the Pareora formation. They have probably no connection with the series of strata with which they have in various reports been associated."

Fossils.

From the shelly sands and soft sandstones of the Mount Brown beds, exposed on the south bank of the Waitaki, half a mile below the junction of the Wharekuri Stream, I made a large collection of fossils, which included the following species :—

1. *Kekenodon onomata*, Hector.
2. *Pleurotoma fusiformis*, Hutton.
3. *Scaphella attenuata*, Hutton.
4. *Scaphella corrugata*, Hutton.
5. *Scaphella fusiformis*, Hutton.
6. *Scaphella pacifica*, Lamarck.

* Reports of Geol. Expls., 1881, pp. 68, 101.

7. *Ancilla lata*, Hutton.
8. *Ancilla hebera*, Hutton.
9. *Natica gibbosa*, Hutton.
10. *Natica darwini*, Hutton.
11. *Cirsotrema browni*, Zittel.
12. *Struthiolaria papulosa*, Martyn.
13. *Calyptræa monoxyla*, Martyn.
14. *Cassidaria sulcata*, Hutton.
15. *Cassidaria senex*, Hutton.
16. *Turritella cavershamensis*, Harris.
17. *Turritella rosea*, Quoy and Gaimard.
18. *Teredo heaphyi*, Zittel.
19. *Dentalium giganteum*, Hutton.
20. *Dentalium mantelli*, Zittel.
21. *Dentalium lævis*, Hutton.
22. *Ostrea angasi* (?), Sowerby.
23. *Anomia alectus*, Gray.
24. *Lima paleata*, Hutton.
25. *Pecten williamsoni*, Zittel.
26. *Pecten scandula*, Hutton.
27. *Pseudamussium huttoni*, Park.
28. *Cucullæa alta*, Sowerby.
29. *Glycimeris striatularis*, Lamarck.
30. *Limopsis insolita*, Sowerby.
31. *Limopsis aurita*, Brocchi.
32. *Cucularia australis*, Hutton.
33. *Panopæa orbita*, Hutton.
34. *Corbula caniculata*, Hutton.
35. *Psammobia lineolata*, Gray.
36. *Pinna zelandica*, Gray.
37. *Mactropsis traili*, Hutton.
38. *Tellina angulata*, Hutton.
39. *Zenatia acinaces*, Quoy and Gaimard.
40. *Nucula nitidula*, Adams.
41. *Magellania novara*, Jhering.
42. *Magellania triangularis*, Hutton.
43. *Trochocyathus mantelli*, M. Edw. and H.
44. *Flabellum radians*, Tenison-Woods.

The fossils in this horizon are very numerous, generally well preserved and easily extracted. The most common species are *Limopsis insolita*, *Venericardia awamoaensis*, *Cucullæa alta*, *Mactropsis traili*, and *Dentalium giganteum*.

Of the forty-one species of *Mollusca* in the above list, ten, or nearly 24·4 per cent., are still living.

Besides prominent molluscs, these sandy beds contain a large number of small and minute forms, many of which are probably new.

From the dirty greensands underlying the *Kekenodon* beds

at the Fishing Rocks, a short distance below the junction of the Wharekuri, I collected the following fossils:—

1. *Aturia australis*, McCoy.
2. *Pleurotoma fusiformis*, Hutton.
3. *Scaphella corrugata*, Hutton.
4. *Turritella cavershamensis*, Harris.
5. *Turritella mantelli*, Zittel.
6. *Cirsotrema brouni*, Zittel.
7. *Natica gibbosa*, Hutton.
8. *Teredo heaphyi*, Zittel.
9. *Pleurotomaria tertiaria*, McCoy.
10. *Ostrea angasi* (?), Sowerby.
11. *Limopsis insolita*, Sowerby.
12. *Pecten hochstetteri*, Zittel.
13. *Pseudamussium huttoni*, Park.
14. *Cucullæa alta*, Sowerby.
15. *Cardium patulum*, Hutton.
16. *Panopæa orbita*, Hutton.
17. *Psammobia lineolata*, Gray.
18. *Mactropsis traili*, Hutton.
19. *Venericardia awamoaensis*, Harris.
20. *Flabellum radians*, Tenison-Woods.

Crab-remains.
Encrinite stem.
Vertebræ of fish.

Of the above, all but *Aturia australis*, *Pleurotomaria tertiaria*, and *Cardium patulum* were found in the *Kekenodon* beds. The fossils of the *Kekenodon* and *Aturia* beds in the Wharekuri basin correlate these beds with the *Kekenodon* and *Aturia* horizons at Kakanui, where the presence of the Oamaru Stone enables us to determine the stratigraphical position of the Mount Brown beds, variously known as Hutchinson Quarry, Kakanui, or Mount Donald beds.

WAIHAO FORKS.

Stratigraphy.

The sequence of the Tertiary beds exposed on the banks of the Waihao River is as follows:—

Waitaki Stone	..	1. Calcareous sandstone.
Mount Brown beds		2. Greensands. 3. Bluish-green sandy clays and sandstones with hard calcareous layers.
Waihao beds	..	4. Bluish-green sandstones. 5. Grey sandstones. 6. Quartzose grits, shales, fireclays, and brown coal.

The succession is almost identical with that seen in the Waitaki Valley. Captain Hutton* contends that beds 3,

* Hutton, "Note on the Geology of the Valley of the Waihao in South Canterbury" (Trans. N.Z. Inst., vol. xix., 1886, p. 480).

which contain what he affirms is a Pareora fauna, overlie the Waihao or Waitaki Stone unconformably. But the stratigraphical evidence, as pointed out by Mr. McKay,* is entirely opposed to this view. The beds containing a Pareora fauna nowhere overlie the Waitaki Stone, but, on the contrary, always occur below or at a lower level than the calcareous sandstone forming that horizon. And along the course of the Waihao and in the small streams which join that river the greensands and bluish-green sandy beds follow the contours of the escarpments in such a way as to everywhere preserve the same relative position with respect to the Waitaki Stone. Captain Hutton attempts to explain this by suggesting that his Oamaru series of Oligocene age was deposited, elevated, sculptured into narrow valleys and channels, and again submerged so as to permit the accumulation of his Pareora beds† in the newly eroded channels. This view supposes that no denudation or erosion of the Waitaki Stone has taken place since the deposition of the supposed Pareoras—that is, since Lower Miocene times—a requirement which it will be difficult to maintain, for physical reasons.

The stratigraphy is not obscure nor the sections involved; and I fully concur with Mr. McKay's interpretation, which is, moreover, borne out by the sections at Black Point, Wharekuri, and Kakahu.

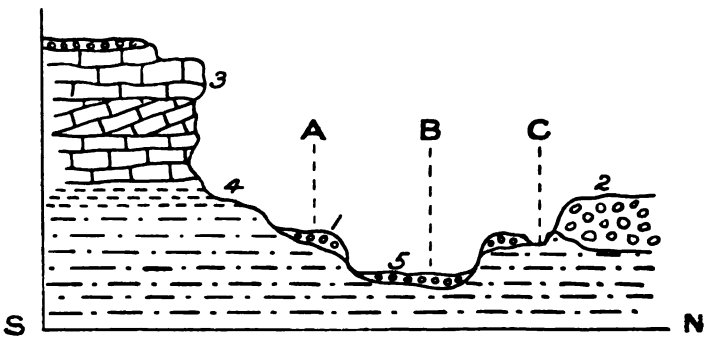

Fig 12.

SECTION AT WAIHAO FORKS ACROSS MAIN BRANCH.

A. Road. B. Waihao River. C. Railway-line. 1. River-gravels. 2. Terrace gravels. 3. Calcareous sandstones, current-bedded; Waitaki Stone. 4. Glauconitic sands and sandstone, Mount Brown beds. 5. Bluish-green sandy clays and sandstones, Waihao sandstone.

* McKay, "The Waihao Greensands, and their Relation to the Ototara Stone" (*loc. cit.*, p. 434).

† Reports of Geol. Expls., 1873–74, p. 37.

The Oamaru building-stone is not represented in the Waihao district.

The Mount Harris beds in this neighbourhood contain a fauna which is the same as that of the Waihao clayey greensands, and, although they rest upon Lower Mesozoic rocks and nowhere overlie the Waitaki Stone, they are referred by the Geological Survey to the Pareora series of Hutton.

The stratigraphy is not very clear, and leaves room for different interpretations, but the palæontological evidence clearly correlates these beds with the Waihao Forks, Black Point, and Hampden beds, which are acknowledged by the Survey to underlie the Waitaki Stone.

Fossils.

From the greensands immediately underlying the Waitaki Stone I collected the following species:—

1. *Kekenodon onomata*, Hector.
2. *Cirsotrema browni*, Zittel.
3. *Pseudamussium huttoni*, Park.
4. *Plagiostoma lævigata*, Hutton.
5. *Magellania parki*, Hutton.
6. *Magellania novara*, Jhering.
7. *Terebratella gaulteri*, Morris.

From the bluish-green sandy clays, the upper greensands of Mr. McKay, I collected the following forms:—

1. *Aturia australis*, McCoy.
2. *Pleurotoma fusiformis*, Hutton.
3. *Siphonalia nodosa*, Martyn.
4. *Scaphella corrugata*, Hutton.
5. *Ancilla australis*, Sowerby.
6. *Ancilla hebera*, Hutton.
7. *Natica darwini*, Hutton.
8. *Natica suturalis*, Hutton.
9. *Cirsotrema browni*, Zittel.
10. *Struthiolaria papulosa*, Martyn.
11. *Turritella rosea*, Quoy and Gaimard.
12. *Turritella kanieriensis*, Harris.
13. *Terebra tristis*, Deshayes.
14. *Teredo heaphyi*, Zittel.
15. *Dentalium mantelli*, Zittel.
16. *Dentalium lævis*, Hutton.
17. *Ostrea wullerstorfi*, Zittel.
18. *Amussium zitteli*, Hutton.
19. *Pseudamussium huttoni*, Park.
20. *Cucullæa alta*, Sowerby.
21. *Cucularia australis*, Hutton.

22. *Limopsis insolita*, Brocchi.
23. *Tellina angulata*, Hutton.
24. *Leda fastidiosa*, Adams.
25. *Trochocyathus mantelli*, M. Edw. and H.
26. *Flabellum radians*, Tenison-Woods.
27. *Balanophyllia hectori*, Tenison-Woods.

There are in the Christchurch Museum a number of species from the Waihao Forks not found by me. They are as follows :—

28. *Pleurotoma hamiltoni*, Hutton.
29. *Barsonia rudis*, Hutton.
30. *Mitra aculeata*, Hutton.
31. *Mitra hectori*, Hutton.
32. *Pecten medius*, Lamarck.
33. *Limopsis aurita*, Brocchi.

Of the thirty molluscs in these lists, seven, or 23·3 per cent., are still living.

Pareora River.

Stratigraphy.

The sections at the lower and upper ends of the Pareora Gorge are so obscure as to be of no value for the determination of the relations existing between the beds containing what has been known as the Pareora fauna and the Oamaru Stone.

At White Rock River, higher up the valley, the Oamaru Stone is absent, but the fossiliferous clays and sandstones exposed there rest upon the basement rock of the district.

Fossils.

From the sandstones at the lower end of the Pareora Gorge, on the south side of the river, in a steep face near the road, where the strata are interbedded with hard calcareous layers, I collected the following forms :—

1. *Ancilla hebera*, Hutton.
2. *Natica darwini*, Hutton.
3. *Turritella rosea*, Quoy and Gaimard.
4. *Turritella cavershamensis*, Harris.
5. *Crepidula monoxyla*, Lesson.
6. *Ostrea wullerstorfi*, Zittel.
7. *Anomia alectus*, Gray.
8. *Lima palæata*, Hutton.
9. *Pseudamussium huttoni*, Park.
10. *Limopsis insolita*, Sowerby.
11. *Glycimeris globosa*, Hutton.

12. *Cucularia australis*, Hutton.
13. *Panopæa orbita*, Hutton.
14. *Corbula caniculata*, Hutton.
15. *Dosinia magna*, Hutton.
16. *Psammobia lineolata*, Gray.
17. *Zenatia acinaces*, Quoy and Gaimard.
18. *Chione crassa*, Quoy and Gaimard.
19. *Chione vellicata*, Hutton.
20. *Tapes curta*, Hutton.

Of the above fossils, six, or 30 per cent., are still living.

From the bluish-green sandy clays at White Rock River I collected the following species:—

1. *Pleurotoma fusiformis*, Hutton.
2. *Siphonalia nodosa*, Martyn.
3. *Siphonalia subnodosa*, Hutton.
4. *Ancilla lata*, Hutton.
5. *Ancilla hebera*, Hutton.
6. *Natica darwini*, Hutton.
7. *Natica zelandica*, Quoy and Gaimard.
8. *Turritella cavershamensis*, Harris.
9. *Turritella kanieriensis*, Harris.
10. *Turritella rosea*, Quoy and Gaimard.
11. *Cirsotrema browni*, Zittel.
12. *Struthiolaria papulosa*, Martyn.
13. *Genota robusta*, Hutton.
14. *Terebra tristis*, Deshayes.
15. *Terebra nitida*, Hinds.
16. *Crepidula monoxyla*, Lesson.
17. *Dentalium giganteum*, Hutton.
18. *Dentalium mantelli*, Zittel.
19. *Dentalium lævis*, Hutton.
20. *Lima paleata*, Hutton.
21. *Pseudamussium huttoni*, Park.
22. *Glycimeris globosa*, Hutton.
23. *Cucullæa alta*, Sowerby.
24. *Chione oblonga*, Hanley.
25. *Tellina angulata*, Hutton.
26. *Dosinia greyi*, Zittel.

Of the twenty-six species in this list, seven, or 28 per cent., are still living.

TENGAWAI RIVER.

From the limestone on the south bank of the Tengawai River, near Cave, I collected the following molluscs:—

1. *Cirsotrema browni*, Zittel.
2. *Ostrea* sp. (?).

3. *Pecten vellicata*, Hutton.
4. *Pseudamussium huttoni*, Park.
5. *Magellania sufflata*, Hutton.
6. *Terebratula tayloriana*, Colenso.
7. *Terebratula oamarutica*, Boehm.
8. *Terebratulina suessi*, Zittel.

These fossils indicate the upper horizon of the Mount Brown beds.

Kakahu Bush, west of Geraldine.

Stratigraphy.

Before reaching Kakahu Bush the Oamaru Stone and the underlying sandstones and sandy-clay beds are repeated by a fault. Sir Julius von Haast* placed this fault in such a position as to make certain sandy clays appear to overlie the Waitaki Stone. Mr. McKay† followed him in this in 1876, and so also did the writer‡ in 1885, no doubt having at that time been expressed as to the stratigraphical position of the Pareora fauna to the Waitaki Stone.

The Geological Survey maintains that the Pareora fauna occurs in beds overlying the Waitaki Stone, while Captain Hutton contends that the sandy clays and greensands believed by the Survey to be below the Waitaki Stone contain the Pareora fauna. The Survey admits the inferior position of the fossiliferous sandstones overlying the coal at Kakahu Bush, but does not acknowledge that the fauna is Pareora. Captain Hutton, while admitting the Pareora facies of the fauna in the Kakahu Bush beds, contends that the beds which contain it do not underlie the Waitaki Stone, but occur in a narrow valley eroded in that rock. It does not appear, however, that he has personally examined the Kakahu section.

As it was important to determine the stratigraphical relationships of the beds admitted by Captain Hutton to contain a Pareora fauna, I devoted my time to an examination of the Kakahu Bush section, where all the members of the Oamaru series are exposed in vertical succession, from the coal-beds, resting upon the Palæozoic rocks, up to the Waitaki Stone. The section exposed there is as follows:—

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* Haast, "Geology of Canterbury and Westland," 1876, p. 310.

† McKay, Reports of Geol. Expls., 1876–77, p. 51.

‡ Park, Reports of Geol. Expls., 1885, p. 170.

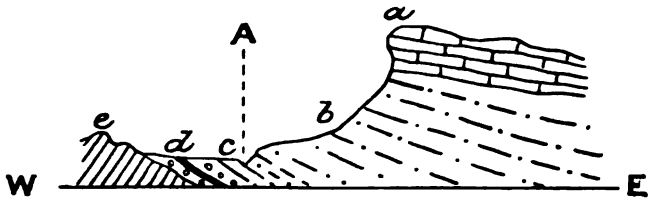


Fig 13.

SECTION AT KAKAHU BUSH.

A. Bush Creek. *a*. Waitaki Stone. *b*. Bluish-green sandstones. *c*. Soft sandstones (greensands) with calcareous bands and masses; fossiliferous. *d*. Quartz grits, brown sands, fireclays, and brown coal. *e*. Claystones and sandstones.

Many sections exactly similar to this are exposed in different parts of the Kakahu Valley.

Fossils.

In the bed of Bush Creek, a few chains above its junction with the Kakahu, I collected from beds *c* the following species :—

1. *Lamna huttoni*, Davis.
2. *Aturia australis*, McCoy.
3. *Terebra tristis*, Deshayes.
4. *Scaphella corrugata*, Hutton.
5. *Siphonalia regularis*, Sowerby.
6. *Siphonalia dilatata*, Quoy and Gaimard.
7. *Ancilla hebera*, Hutton.
8. *Natica darwini*, Hutton.
9. *Struthiolaria papulosa*, Martyn.
10. *Crassatellites ampla*, Hutton.
11. *Crassatellites australis*, Hutton.
12. *Cassidaria senex*, Hutton.
13. *Calyptræa monoxyla*, Martyn.
14. *Turritella rosea*, Quoy and Gaimard.
15. *Turritella cavershamensis*, Harris.
16. *Turritella kanieriensis*, Harris.
17. *Teredo heaphyi*, Zittel.
18. *Dentalium mantelli*, Zittel.
19. *Dentalium lævis*, Hutton.
20. *Ostrea wullerstorfi*, Zittel.
21. *Anomia alectus*, Gray.
22. *Pecten williamsoni*, Zittel.
23. *Pseudamussium huttoni*, Park.
24. *Lima paleata*, Hutton.
25. *Cucularia australis*, Hutton.
26. *Panopæa orbita*, Hutton.

27. *Corbula caniculata*, Hutton.
28. *Chione crassa*, Quoy and Gaimard.
29. *Chione vellicata*, Hutton.
30. *Dosinia magna*, Hutton.
31. *Cucullæa alta*, Sowerby.
32. *Glycimeris globosa*, Hutton.
33. *Leda fastidiosa*, Hutton.
34. *Flabellum radians*.
35. *Balanophyllia hectori*, Tenison-Woods.

There are several species in the Kakahu collection in the Canterbury Museum which were not found by me. They are as follows:—

36. *Scaphella kirki*, Hutton.
37. *Struthiolaria spinosa*, Hutton.
38. *Ostrea angasi*, Sowerby.
39. *Pinna zelandica*, Gray.

Of the thirty-six molluscs in the above list, ten, or 28 per cent., are still living.

Trelissic Basin.

This place was examined by Sir Julius von Haast in 1867, examined and mapped by Sir James Hector in 1872, by Mr. McKay in 1879,* and by Captain Hutton in 1886.† Last April I spent four days examining the section along the course of the Thomas River, which runs through the centre of the basin. Every one had given a different interpretation of the geology of the basin, and for that reason I devoted my time to one section, in the hope that I should be able to arrive at some definite conclusion as to the sequence and relationship of the different beds. In this I was disappointed.

The Cretaceous and Tertiary beds are not folded so as to be involved in the tectonic arrangement of the mountains which surround the basin; but they are faulted, disturbed by volcanic intrusions, and covered over wide areas by heavy deposits of terrace gravels, which make it impossible to get a continuous section in any direction across the basin. It is for these reasons that the sections shown by Sir James Hector‡ are so unlike those drawn by Captain Hutton.§ I agree with Sir James Hector and Mr. McKay in correlating the lower limestone with the Weka Pass Stone. But Mr. McKay goes further than this. He correlates the lower limestone (Weka Pass Stone) with the Ototara Stone (Waitaki Stone), a view

* Reports of Geol. Expls., 1879–80, p. 54.
† Hutton, "On the Geology of the Trelissic or Broken River Basin, Selwyn County" (Trans. N.Z. Inst., vol. xix., 1886).
‡ Reports of Geol. Expls., 1879–80, p. xx.
§ Trans. N.Z. Inst., vol. xix., 1886, p. 408.

advanced without evidence, but in conformity with the Cretaceo-Tertiary theory of the Geological Survey.

As will be shown anon, the Weka Pass Stone is the closing member of the Waipara series, and the Waitaki Stone the closing member of the Oamaru series. The former is a hard limestone, often flaky and fucoidal, and practically devoid of molluscous fossils; the latter a soft coralline crag, with well-known characteristic molluscs, corals, and echinoderms.

The lower limestone (Weka Pass Stone) is followed unconformably by a considerable thickness of tuffs, impure limestone, and calcareous sandstones, containing many of the brachiopods, pectens, corals, &c., of the Kakanui limestones and tuffs.

These beds are followed by fossiliferous sandstones, shelly sands, sandstones, and clays with brown coal.

The fossiliferous sandstone contains a number of large molluscs, including *Dosinia magna*, *Tapes curta*, *Cardium spatiosum*, *Crassatellites ampla*, *Glycimeris globosa*, *Cucullæa ponderosa*, *Turritella cavershamensis*, and *Dentalium giganteum*. Many other forms characteristic of the Oamaru series are recorded by Captain Hutton and Mr. McKay, and need not be enumerated here, as there is no means of determining the relationship between the beds which contain them and the Waitaki Stone.

It may be of interest to mention that I discovered a fossiliferous horizon not hitherto recorded. On the west bank of the stream which the coach-road crosses before ascending the sideling cutting leading on to the terrace on which Castle Hill Hotel is situated, at a point about 15 chains below the crossing, there is an outcrop of blue sandy clay containing a band of *Ostrea ingens*, Zittel, in a fine state of preservation, and as large as the examples found at Waitotara. At the same place I collected *Calyptræa scutum*, Lesson.

The oyster-bed appears to lie some distance above the shelly sands and sandstones at the upper end of the gorge of the Thomas River.

So far as I am aware, *Ostrea ingens* has not been recorded from the South Island until now. It is a shell distinctly characteristic of the Te Aute series in the North Island, and its presence in the Trelissic basin suggests the question, Are the Motanau beds present in that area?

WAIPARA AND WEKA PASS.

Stratigraphy.

This district has been examined very frequently, and, although the stratigraphy is very clear and free from involvement, much confusion has arisen through the endeavours of

some of the writers, myself included, to interpret the sections in conformity with the Cretaceo-Tertiary theory of the Geological Survey. According to this theory the Weka Pass Stone is the equivalent of the Waitaki Stone. Below the Weka Pass Stone there is a succession of beds closely resembling those found below the Waitaki Stone, and containing a Secondary fauna: therefore the theory was held to be proved. But this contention overlooked the manifest fact that the succession of fossiliferous Tertiary beds which underlie the Waitaki Stone in Otago and South Canterbury overlie the Weka Pass Stone at Weka Pass, forming the Mount Donald and Mount Brown Ranges.

The Geological Survey has always acknowledged that the Mount Donald beds overlaid the Weka Pass Stone, but has not recognised that the Mount Donald, Mount Brown, or Hutchinson Quarry beds underlaid the Waitaki Stone, as I have shown to be the case at Kakanui and Wharekuri.

The resemblance of the sequence and character of the rocks of the Waipara and Oamaru formations was noticed by Sir Julius von Haast. That writer, when discussing the Oamaru formation in 1879, said,* "The beds belonging to the Oamaru formation resemble often in sequence and character of the rocks those of the preceding Waipara formation. They in most instances begin with littoral deposits and end with calcareous strata, the latter formed in deeper water."

In this district there are three easily recognised marine formations—namely, (1) Motanau beds, of Older Pliocene age; (2) Oamaru series, of Miocene age; (3) Waipara series, of Upper Cretaceous age. These formations are met in the order named on the railway-line between Waipara Station and the upper end of Weka Pass.

Motanau Beds.

At 42 miles 30 chains from Christchurch, after the line leaves the gravel terrace of the Waipara, there appear in the railway cuttings brown sands with layers of hard flaggy sandstone, often pebbly and gritty, and generally calcareous. The dip of these beds is easterly at very low angles, and, proceeding along the railway-line, sandstones, sandy clays, and shell-beds succeed each other for a distance of three-quarters of a mile.

In the cutting between the 42½-mile and the 43¾-mile posts there are a number of conspicuous oyster-shell beds occurring throughout a thickness of about 100 ft. These marine beds end at a point 10 chains north of the 43-mile

* Haast, "Geology of Canterbury and Westland," 1879, p. 305.

post. They are, according to Captain Hutton,* about 370 ft. thick. From the shell-beds above the oyster-beds I collected the following species :—

1. *Purpura textiliosa*, Agassiz.
2. *Siphonalia dilatata*, Quoy and Gaimard.
3. *Siphonalia orbita*, Hutton.
4. *Euthria lineata*, Martyn.
5. *Nassa incisa*, Hutton.
6. *Ancilla australis*, Sowerby.
7. *Scaphella pacifica*, Lamarck.
8. *Lotorium spengleri*, Lamarck.
9. *Natica gibbosa*, Hutton.
10. *Calyptræa calyptræformis*, Lamarck.
11. *Turritella rosea*, Quoy and Gaimard.
12. *Turritella kanieriensis*, Harris.
13. *Ethalia zealandica*, Homb. and Jacq.
14. *Calliostoma punctulatum*, Martyn.
15. *Panopæa orbita*, Hutton.
16. *Mactra discors*, Gray.
17. *Zenacia acinaces*, Quoy and Gaimard.
18. *Mesodesma novæ-zealandiæ*, Chemnitz.
19. *Chione vellicata*, Sowerby.
20. *Chione stutchburyi*, Gray.
21. *Meretrix multistriata*, Sowerby.
22. *Dosinia australis*, Gray.
23. *Venericardia australis*, Lamarck.
24. *Glycimeris laticostata*, Quoy and Gaimard.
25. *Glycimeris globosa*, Hutton.
26. *Pecten zelandiæ*, Gray.
27. *Anomia alectus*, Gray.
28. *Ostrea angasi*, Linné.

Balanus (sp. ?).
Fish-teeth.

Of the twenty-eight species of molluscs enumerated above, twenty, or 71 per cent., are still living.

The species of oyster in the oyster-beds appear to be *Ostrea angasi* and *Ostrea agglomerata*, or varieties of these.

Below the oyster-beds there are loose pebbly shell-beds from which I collected the following species :—

1. *Carcharodon carcharias*, Müller.
2. *Siphonalia dilatata*, Quoy and Gaimard.
3. *Ancilla australis*, Sowerby.
4. *Turritella rosea*, Quoy and Gaimard.
5. *Crepidula monoxyla*, Lesson.

* Hutton's "On some Railway Cuttings in the Weka Pass" (Trans. N.Z. Inst., vol. xx., 1887, p. 257).

6. *Dentalium majus*, Hutton.
7. *Zenacia acinaces*, Quoy and Gaimard.
8. *Chione vellicata*, Sowerby.
9. *Chione stutchburyi*, Gray.
10. *Meretrix assimilis*, Hutton.
11. *Dosinia australis*, Gray.
12. *Venericardia australis*, Lamarck.
13. *Glycimeris globosa*, Hutton.
14. *Pecten radiatus*, Hutton.
15. *Ostrea angasi*, Sowerby.
16. *Anomia alectus*, Gray.
17. *Psammobia lineolata*, Gray.
18. *Mactra æquilatera*, Deshayes.
19. *Tapes intermedia*, Quoy and Gaimard.

Of the eighteen molluscs in this list, thirteen, or 61 per cent., are still living, a percentage which clearly places these and the associated beds in the Pliocene.

The Motanau beds, although correlated by the Geological Survey with the Pareora series, contain none of the shells characteristic of the Pareora fauna. As will be shown presently, the Pareora fauna occurs in the underlying Mount Brown or Mount Donald beds.

The Motanau beds rest upon a denuded surface of the underlying Mount Brown beds. The unconformity between the two series was recognised by Sir James Hector* in 1868, and by Sir Julius von Haast† in 1870. Both writers referred these beds to the Pliocene. The former noted that the beds contained "many specimens of marine shells that are still alive," and had been deposited "in basins excavated in the older Tertiary rocks"—that is, in the Mount Brown beds. After an interval of thirty-four years I am compelled to once more refer the Motanau beds back to the Pliocene.

Mount Brown Beds.

At 43 miles 3 chains from Christchurch the railway-line enters a cutting which is a little over 6 chains long. The bank on the west or Weka Stream side of the line rises from a few feet high at the lower end to 26 ft. high near the north end, whence it drops to nothing somewhat more abruptly. The section exposed in this cutting is of great importance, as here the Motanau beds are seen to rest unconformably upon the Mount Brown beds. The Motanau beds lie on a denuded surface of the Mount Brown beds, and the section is so clear that no doubt can be entertained as to the unconformable

* Hector, Progress Report, p. xii., Reports of Geol. Survey, 1868–69.
† Haast, Reports of Geol. Expls., 1870–71, p. 15.

relations of the two formations. Fig. 14 shows the general arrangement of the beds exposed in the bank on the west side of the cutting:—

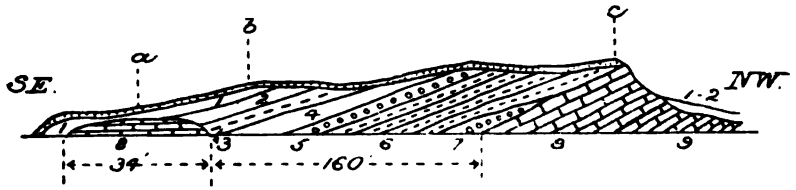


Fig 14.

SECTION FROM 43 M. 3 CH. TO 43 M. 9 CH., LOOKING TOWARDS WEKA PASS CREEK.

1. Shelly sands. 2. Brown sands. 3. Shell-bed. 4. Sands. 5. Pebbly shell-bed. 6. Sands 7. Pale-greenish-coloured sands. 8. Coralline limestone. 9. Brown sandstone with calcareous layers.

Beds 1 to 7 are the Motanau beds; 8 and 9 the upper horizons of the Mount Brown beds. At point *a* the coralline beds rise in the bank to a height of 7 ft. At *b* the cutting is about 20 ft. high, and at *c* about 26 ft.

From bed 8, which is a coralline crag, I collected the following forms:—

1. *Ostrea wullerstorfi*, Zittel.
2. *Pecten hutchinsoni*, Hutton.
3. *Pecten beethami*, Hutton.
4. *Pecten*, 2 sp. nov.
5. *Lima paleata*, Hutton.
6. *Plagiostoma lævigata*, Hutton.
7. *Dosinia greyi*, Zittel.
8. *Magellania novara*, Jhering.
9. *Magellania sufflata*, Hutton.
10. *Magellania parki*, Hutton.
11. *Rhynchonella nigricans*, Sowerby.
12. *Meoma crawfordi*.

Balanus.

Corals and *Cidaris* spines in great abundance.

Many of these fossils distinguish the highest fossiliferous horizon underlying the Oamaru Stone in North Otago.

On passing through the cutting just described, and shown in fig. 14, the line crosses a gully excavated in soft brown sandstones, which are best seen on the back of Mount Donald, a short distance to the north.

Before reaching the 44-mile post the line passes through a heavy cutting in the rubbly impure limestones and sandstones which form the crown of Mount Donald, whence they descend

to the railway, cross the valley, and stretch westward to Mount Brown.

This horizon of impure limestone and calcareous sandstone can be traced for miles along the crest of Mount Donald and Mount Brown, forming a steep escarpment facing the northern aspect of these ridges. In some places it is crowded with fossils, in others almost destitute of them.

At Weka Pass fossils are not very abundant, and for some distance along the escarpment going towards Mount Donald very few are seen excepting corals. Some mile and a half north of the pass, near the highest part of Mount Donald, the beds become richly fossiliferous for a stretch of 15 chains. At this place I made a large collection of well-preserved fossils, which included the following species :—

1. *Kekenodon onomata* (?), Hector.
2. *Carcharodon megalodon*, Agassiz.
3. *Aturia australis*, McCoy.
4. *Pleurotoma awamoaensis*, Hutton.
5. *Scaphella elongata*, Hutton.
6. *Scaphella corrugata*, Hutton.
7. *Siphonalia nodosa*, Martyn.
8. *Ancilla hebera*, Hutton.
9. *Natica gibbosa*, Hutton.
10. *Cirsotrema browni*, Zittel.
11. *Crepidula monoxyla*, Lesson.
12. *Calyptræa ca yptræformis*, Lamarck.
13. *Cassidaria senex*, Hutton.
14. *Turritella cavershamensis*, Harris.
15. *Xenophora* (sp. ?).
16. *Dentalium mantelli*, Zittel.
17. *Ostrea wullerstorfi*, Zittel.
18. *Ostrea angasi* (?).
19. *Anomia alectus*, Gray.
20. *Lima paleata*, Hutton.
21. *Lima bullata*, Born.
22. *Pecten beethami*, Hutton.
23. *Pecten williamsoni*, Zittel.
24. *Pecten hutchinsoni*, Hutton.
25. *Pecten* (sp. nov.).
26. *Pseudamussium huttoni*, Park.
27. *Cucullæa alta*, Sowerby.
28. *Glycimeris globosa*, Hutton.
29. *Glycimeris striatularis*, Lamarck.
30. *Limopsis insolita*, Sowerby.
31. *Dosinia magna*, Hutton.
32. *Dosinia greyi*, Zittel.
33. *Panopæa orbita*, Hutton.

34. *Psammobia lineolata*, Gray.
35. *Chione vellicata*, Hutton.
36. *Venericardia awamoaensis*, Harris.
37. *Mactropsis traili*, Hutton.
38. *Tellina angulata*, Hutton.
39. *Mytilus magellanicus* (?), Chemnitz.
40. *Bouchardia concentrica*, Hutton.
41. *Bouchardia elongata*, Hutton.
42. *Magellania parki*, Hutton.
43. *Magellania insolita*, Hutton.
44. *Magellania novara*, Jhering.
45. *Magellania triangularis*, Hutton.
46. *Terebratula oamarutica*, Boehm.
47. *Balanus* (sp.?).
48. *Meoma crawfordi*, Hutton.

The fossils enumerated in this list are those found, with a few exceptions, in the fossiliferous horizons below the Waitaki Stone at Kakanui, and include the majority of the species held to be characteristic of the Pareora fauna. Of the *Mollusca*, nine, or nearly 20 per cent., are still living.

In Mount Donald and Mount Brown there is a second band of impure rubbly limestone lying several hundred feet below the band which occupies the summit of the ridges. It is mainly composed of corals and cup-shaped bryozoans, but, unlike the upper band, contains very few distinct molluscs on the slopes of Mount Donald ridge facing the pass. The two bands of limestone form lines of conspicuous escarpment on the northern aspect of Mount Donald. They are separated by soft brown sandstones, which are not well exposed except in the railway cuttings. The lower band of limestone rests conformably on bluish-green and grey sandstones, which are well exposed in the steep banks of Weka Stream below the railway-line. These beds form the "grey marls" of the Geological Survey. In them I found *Amussium zitteli*, Hutton, a small *Dentalium*, and a few small bivalves too indistinct for identification.

In the higher part of the small shallow valley which runs from the viaduct eastward under Mount Donald the slopes are covered with large masses of hard calcareous sandstone and conglomerate often crowded with brachiopods, *Pseudamussium huttoni*, *Cucullæa*, &c. I could not satisfy myself as to whether these masses were derived from the lower calcareous horizon or had fallen from the summit of Mount Donald.

In his section from the Waipara River across Mount Brown, a few miles south-west of Mount Donald, Haast* shows a series of *Cucullæa* beds resting directly upon the

* Haast, *loc. cit.*, p. 18.

Weka Pass Stone at the foot of Mount Brown, in a position that would correspond with that of the supposed lower *Cucullæa* horizon at Mount Donald, Wharekuri, and Kakanui.

In places where the Mount Brown beds are in contact with the Weka Pass Stone the relation existing between the two formations is not very distinct, the upper formation consisting of soft sandstones naturally conforming more or less completely to the surface of the hard Weka Pass Stone. But the mapping of the rocks puts a different complexion upon the question, and brings out the unconformable relations of the Tertiary to the Cretaceous formation in a very clear manner. Thus, at the 45-mile post the lower, but not the lowest, of the Tertiary beds rests upon the Weka Pass Stone and its associate the Amuri limestone; and a short distance before reaching the viaduct the same or even lower Tertiary beds rest against the greensands which underlie the Amuri limestone.

Further, the Weka Pass Stone and Amuri limestone are thrown into folds in which the Tertiaries take no part whatever.

The unconformity between the Mount Brown beds and the Weka Pass Stone was recognised by Sir James Hector* in 1868. The former he referred to the Miocene, and the latter to the Waipara formation of Hochstetter. Haast† was also satisfied, in 1870, as to the unconformable relations of the two formations. In reference to this point he wrote, "That the denudation of the Weka Pass beds [Weka Pass Stone and Amuri limestone] had taken place previously to the deposition of the *Cucullæa* beds No. 11 is well shown in the sections Nos. 6 and 7, where the Weka Pass beds stand as isolated islands between the latter, abutting unconformably against them."

Apart from the stratigraphy, the palæontological break is complete; and I do not think that any one will now seriously contend that a formation which contains a Miocene fauna is conformable to a formation containing saurians and other Secondary forms.

Waipara Series.

(Syn. Waipara Formation, Hochstetter, 1866.)

The sequence of the rocks belonging to this formation in the Weka Pass and Waipara districts is as follows:—

1. Weka Pass Stone.
2. Amuri limestone.
3. Glauconitic greensands.
4. Greensands, often argillaceous with saurian boulders, sometimes covered with a crust of cone-in-cone limestone.

* Hector, Progress Report, Report of Geol. Survey, 1868–69, p. xii.
† Haast, Reports of Geol. Expls., 1870–71, p. 16.

5. Black-oyster bed with *Conchothyra parasitica*, McCoy.
6. Quartzose sands with shale and brown coal.
7. Quartzose sands with bands of limonitic sandstone.

The full succession is exposed in the Waipara Valley, between Ram Paddock and the slopes of Doctor's Range; but only beds 1, 2, and 3 are seen in the Weka Pass, the direction of the dip not permitting the exposure of the lower beds.

The general arrangement of the Weka Pass Stone and Amuri limestone on the west side of the stream is very well seen from the railway-line, standing at a point near the 45-mile post. The section from the lower to the upper end of the gorge is as shown in fig. 15.

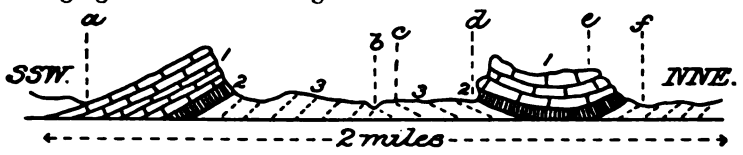


Fig 15.

SECTION ALONG WEST SIDE OF WEKA PASS.

a. Lower end of pass. *b*. Small stream. *c*. Opposite 45-mile post. *d*. 45½-mile. *e*. Opposite viaduct. *f*. Upper end of gorge. 1. Weka Pass Stone. 2. Amuri limestone. 3. Upper greensands.

The section exposed at the 45-mile post, running from the pass eastward to Mount Donald Range, is shown in fig. 16.

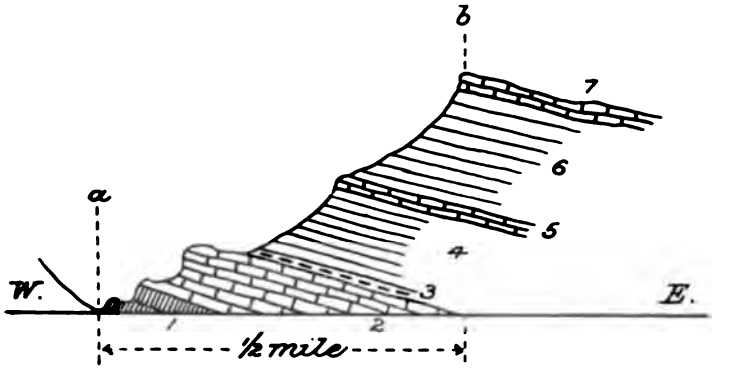


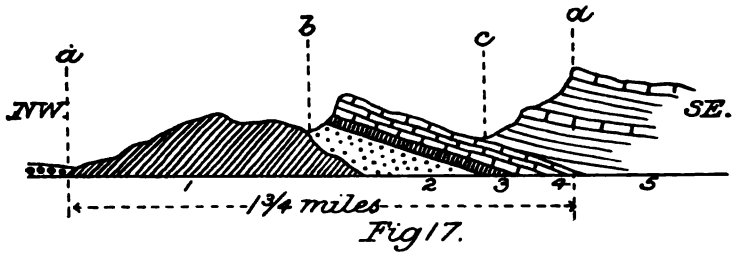
Fig 16.

SECTION FROM PASS EASTWARD.

a. Weka Pass. *b*. Mount Donald Range. Waipara series: 1, Amuri limestone; 2, Weka Pass Stone. Oamaru series: 3, Blue sandy clays; 4, brown and greenish-grey sandstones; 5, band of impure limestone (coralline) about 24 ft. thick; 6, soft brown sandstones, fossiliferous in upper part; 7, calcareous sandstone, richly fossiliferous in places.

Bed 4 corresponds with the grey marls of the Geological Survey and the *Cucullæa* beds of Haast at Mount Brown. The lower coralline limestone occupies the stratigraphical position of the Oamaru building-stone, and is doubtless the local representative of that horizon.

The arrangement of the Waipara and Tertiary beds is very well seen near the upper end of Weka Pass, in the line of section from Waikari Flats across to Mount Donald Range. It is shown in fig. 17 below.



SECTION FROM WAIKARI FLATS TO MOUNT DONALD RANGE.

a. Waikari Flat. *b*. South-east boundary-line of Section 8198. *c*. Valley opposite viaduct. *d*. Mount Donald Range. 1. Palæozoic or Secondary claystones and sandstones. 2. Glauconitic greensands. 3. Amuri limestone. 4. Weka Pass Stone. 5. Tertiary beds.

Weka Pass Stone.—This is generally a hard grey limestone, sometimes sandy and flaky, and in places crowded with fucoid-like markings. At the north side of the viaduct, at the upper end of the gorge, it is about 125 ft. thick. An average sample of the rock broken from the whole thickness showed the following composition. The analyses of Amuri limestone, Weka Pass Stone, and Oamaru Stone were made by Dr. Maclaurin, D.Sc., Government Analyst:—

	Oamaru Stone.*	Weka Pass Stone.†
Calcium-carbonate ...	93·90	67·60
Magnesium-carbonate ...	1·00	0·80
Calcium-oxide	...	0·80
Alumina	0·51	3·92
Iron-oxide (Fe_2O_3) ...	0·69	2·08
Silica	2·75	22·51
Organic matter and water	1·15	2·29
Undetermined	...	...
	100·00	100·00

* Oamaru Stone from Totara Quarry, near Oamaru.

† Weka Pass Stone from Waikari, end of Weka Pass, from cliffs on north side of stream, a few chains above the railway viaduct.

These are the analyses not of a single rock-specimen, but of average samples selected from the total thickness of the beds. The Weka Pass Stone contains a high proportion of silica and a low proportion of calcium-carbonate, and is a very poor sandy limestone. The Oamaru Stone is a high-class limestone, remarkably low in alumina, iron-oxide, and silica.

The Weka Pass Stone varies considerably in composition, being more calcareous in the higher than the lower portion. Near its junction with the Amuri limestone it is merely a calcareous sandstone, as shown by the analysis of an average sample selected about 2 ft. above the Amuri limestone:—

	Weka Pass Stone (2 ft. above Amuri Limestone).
Calcium-carbonate	47·62
Magnesium-carbonate	1·46
Calcium-oxide	1·50
Alumina	6·44
Iron-oxide (Fe_2O_3)	2·76
Silica	34·95
Organic matter and water	3·50
Undetermined	1·77
	100·00

The following analyses are interesting as showing that the Amuri limestone becomes more siliceous as it approaches the Weka Pass Stone:—

	Average Sample from Thickness of 40 ft.	Sample from 2ft. below Weka Pass Stone.
Calcium-carbonate ...	88·64	81·56
Magnesium-carbonate ...	0·45	0·61
Calcium-oxide	...	...
Alumina	0·66	1·03
Iron-oxide (Fe_2O_3) ...	0·54	0·77
Silica	7·25	14·45
Organic matter and water	2·06	1·58
Undetermined	0·40	...
	100·00	100·00

The Weka Pass Stone seems to be entirely destitute of molluscan fossils. I spent many hours searching acres of its bare weathered surfaces, and only succeeded in finding a few broken echinoderm spines and a thin calcareous tube. The ganger or foreman at the railway quarry near the 45-mile post, in reply to my inquiries, informed me that he had never seen a trace of fossils in the stone, of which thousands of tons had been broken.

Many large masses of the rusty-brown fossiliferous calcareous sandstone which crowns the Mount Donald Range overlooking the railway-line are strewn on the surface both above and below the outcrop of the Weka Pass Stone in the pass in the vicinity of the quarry. I am inclined to think that many of the fossils credited to the Weka Pass Stone were in reality obtained from these masses.

Sir Julius von Haast,* in his report on the geology of Waipara district in 1869, gives a list of fossils purporting to come from the Weka Pass Stone, and then further on admits that the greater part of the fossils came from the Curiosity Shop beds. The species he enumerates are the fossils characteristic of the Mount Brown beds. Nearly all of them are present at Mount Donald, and can be collected from the loose fallen masses lying in Weka Pass, near the railway-line. Certainly none of them occur in the Weka Pass Stone.

The Weka Pass Stone has been correlated by the Geological Survey with the Oamaru Stone† for more than thirty years, and the characteristic fossils of the Oamaru Stone have been credited to Weka Pass Stone. I can find no record of the grounds upon which this correlation was made. It certainly was not founded upon similarity of fossil contents, or even lithological characters.

The Oamaru Stone is underlain by beds containing a Tertiary fauna; the Weka Pass Stone by beds containing a purely Secondary fauna. Further, the Tertiary fauna found below the Oamaru Stone in North Otago and South Canterbury occurs above the Weka Pass Stone in the Weka Pass, thus proving in the most conclusive manner that the Waitaki Stone cannot be the equivalent of the Weka Pass Stone. The correlation was apparently based upon the resemblance of the escarpments and weathered outcrops of the two rocks. It gave an erroneous conception of the relationship existing between our Tertiary and Upper Secondaries, and may be held chiefly responsible for the Cretaceo-Tertiary theory of the Geological Survey.‡

Captain Hutton contends that there is an unconformity between the Weka Pass Stone and the Amuri limestone. I carefully examined the line of contact of the two rocks, but was unable to find any evidence of unconformity; and on this point my view coincides with that of Sir James Hector, Sir Julius von Haast, and Mr. McKay.

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* Haast, Reports of Geol. Expls., 1870–71, p. 13.

† The Geological Survey has always been of the belief that there is only one limestone in the Oamaru district. The Oamaru or Ototara Stone of the Survey refers in nearly all cases to the Waitaki Stone, or closing member of the Oamaru series, and not to the Oamaru building-stone.

‡ Hector, Reports of Geol. Survey, 1866–67, p. 17.

LOWER AWATERE.

The Awatere beds are well exposed on the banks of the Awatere River, both above and below the railway-bridge near the Township of Seddon, and also in the bed of Starborough Creek, which flows through Seddon, and joins the Awatere a little over a quarter of a mile below the bridge. The lower beds consist of blue clays, which often contain large limestone concretions; and the higher beds, of sandy beds and sandstones, which are interbedded with thin layers of harder shelly sandstone, generally crowded with shells. The clay beds contain only a few fossils. The higher sandy beds, on the other hand, are richly fossiliferous, the shells being well preserved and easily extracted.

A collection made from the upper beds as exposed on the bank of the Awatere, at the mouth of Starborough Creek, contained the following forms :—

1. *Siphonalia dilatata*, Quoy and Gaimard.
2. *Siphonalia mandarina*, var. *cordata*, Quoy and Gaimard.
3. *Siphonalia subnodosa*, Hutton.
4. *Siphonalia conoidea*, Hutton.
5. *Struthiolaria sulcata*, Hutton.
6. *Struthiolaria vermis*, Martyn.
7. *Struthiolaria papulosa*, Martyn.
8. *Struthiolaria cincta*, Hutton.
9. *Scaphella corrugata*, Hutton.
10. *Scaphella pacifica*, Lamarck.
11. *Turritella rosea*, Quoy and Gaimard.
12. *Turritella kanieriensis*, Harris.
13. *Cirsotrema zelebori*, Frauenfeld.
14. *Cattiostoma selectum*, Chemnitz.
15. *Natica ovata*, Hutton.
16. *Natica zelandica*, Gray.
17. *Ancilla australis*, Sowerby.
18. *Cylichna striata*, Hutton.
19. *Cantharidus purpuratus*, Martyn.
20. *Monilea egena*, Gould.
21. *Dentalium conicum*, Zittel.
22. *Ostrea angasi*, Sowerby.
23. *Anomia walteri*, Hector.
24. *Pinna zelandica*, Gray.
25. *Mytilus magellanicus*, Chemnitz.
26. *Glycimeris laticostata*, Quoy and Gaimard.
27. *Pecten convexus*, Quoy and Gaimard.
28. *Pecten triphooki*, Hutton.
29. *Chione oblonga*, Hutton.
30. *Chione stutchburyi*, Gray.

31. *Dosinia magna*, Hutton.
32. *Dosinia greyi*, Zittel.
33. *Cardium spatiosum*, Hutton.
34. *Cardium striatulum*, Sowerby.
35. *Corbula dubia*, Hutton.
36. *Zenatia acinaces*, Quoy and Gaimard.
37. *Panopæa plicata*, Hutton.
38. *Tapes*, sp. nov.
39. *Diplodonta zelandica*, Gray.

Of the forty-two species enumerated above, thirty, or 71·4 per cent., are still living. There is no difficulty in correlating these beds with the Motanau beds of North Canterbury and the Te Aute series of Wellington and Hawke's Bay.

Port Hills, Nelson.

Stratigraphy.

The Tertiaries of Nelson consist of conglomerates followed by coarse sandstones, which are succeeded by finer banded sandstones and sandy clays. The conglomerates form Arrow Rock, at the entrance to the harbour. The coarse sandstones contain gritty shell and coral beds, and are well exposed below high-water mark as reefs lying between Arrow Rock and the sea-wall. The finer sandstones are best seen in the cliffs facing the harbour.

A few isolated boulders of granite partially water-worn occur imbedded in the upper sandstones. The largest boulder seen by me was about 4 ft. in diameter. The material composing the great conglomerate at the base of the series is said to be mainly granitic.

The beds are tilted towards the south-east—that is, towards the Port Hills—at angles varying from 70° in the lower sandstones to 45° in the higher. They run more or less parallel with the sea-wall, but in places are seen to be faulted and even bent along the strike. The direction of the dip carries them under the Port Hills, themselves composed of gravels which appear to be a remnant of the Moutere gravels of Pleistocene age.

The well-known Waimea, Moutere, and Motueka gravel hills are all that now remain of the great sloping fan or plain formed by the Motueka River at the time when it drained the slopes of the Spenser Mountains and Mount Murchison, and wandered from Richmond to Riwaka, a slow sinking of the land enabling it to carry forward the material by means of which half of Tasman Bay was reclaimed from the sea. The outline of this great river-fan can still be clearly traced from the shores of Tasman Sea south-westward to the sources of the Hope River, where it attains a

height of over 2,000 ft. in a distance of little over thirty miles as the crow flies.

By the recision of its head-streams the Buller River has cut its course back into the watershed of its eastern neighbour, thereby diverting the drainage from the Spensers into its own channel. That the recision of the head-waters of the Buller has taken place since the retreat of the glaciers is almost quite certain, but the cause of the recision is not very evident. Whether it was due to the physical condition and favourable arrangement of the rocks for erosion or faulting, or the differential elevation of the land, or to a combination of these causes, is a subject that awaits further investigation.

Fossils.

From the gritty sandstones exposed at low water below the sea-wall about half-way around the Port Hills Road to the Waimeas I collected the following fossils:—

1. *Aturia australis*,* McCoy.
2. *Pleurotoma fusiformis*, Hutton.
3. *Siphonalia nodosa*, Hutton.
4. *Scaphella pacifica*, Lamarck.
5. *Scaphella corrugata*, Hutton.
6. *Struthiolaria papulosa*, Martyn.
7. *Cirsotrema browni*, Zittel.
8. *Natica darwini*, Hutton.
9. *Turritella cavershamensis*, Harris.
10. *Turritella kanieriensis*, Harris.
11. *Crepidula monoxyla*, Lesson.
12. *Calyptræa calyptræformis*, Lamarck.
13. *Teredo heaphyi*, Zittel.
14. *Dentalium mantelli*, Zittel.
15. *Ostrea wullerstorfi*, Zittel.
16. *Pecten williamsoni*, Zittel.
17. *Glycimeris globosa*, Hutton.
18. *Cucullæa alta*, Sowerby.
19. *Solenotellina nitida*, Gray.
20. *Flabellum radians*, Tenison-Woods.
21. *Flabellum sphenodeum*, Tenison-Woods.
22. *Trochocyathus mantelli*, M. Edw. and H.

Besides these, the following forms are recorded by Hochstetter as having been found by him in the Port Hills cliffs:—

* The *Aturia* occurs in a crumbling gritty sandstone, close to the sea-wall, at a point about 18 chains south of the "basin," and worn smooth by the wash of the tide at high water. The exact spot was shown to my old friend Mr. W. S. Curtis, of the Government Survey Department, Nelson, who will be glad to point out the place to any one interested in our Tertiary geology.—J. P.

23. *Siphonalia robinsoni*, Zittel.
24. *Scaphella gracilicostata*, Zittel.
25. *Limopsis insolita*, Sowerby.
26. *Glycimeris laticostata*, Quoy and Gaimard.
27. *Solenella australis*, Zittel.

Of the twenty-four molluscs in the above lists, seven, or 29 per cent., are still living. The fossils clearly refer these beds to the Oamaru series.

About 11 ft. below the *Aturia* bed there is a gritty shell-bed crowded with broken corals and *Cidaris* spines. It varies from nothing to 6 ft. in width, its outcrop presenting the appearance of a truncated lens. It was from this bed that the bulk of the fossils collected by me were obtained.

Résumé.

The conclusions I have arrived at relative to the physical and stratigraphical geology of New Zealand, based upon the foregoing facts, may be summarised as follows :—

(*a.*) That the main orographical features were determined soon after the close of the Jurassic.

(*b.*) That there are three Tertiary marine formations in New Zealand, as under :—(1.) Wanganui series: Newer Pliocene. (2.) Te Aute or Waitotara series: Older Pliocene. (3.) Oamaru series: Miocene.

(*c.*) That the Oamaru series rests unconformably upon the Waipara series of Upper Cretaceous age.

(*d.*) That the Waipara, Oamaru, and Waitotara series are marginal deposits which accumulated during periods of partial submergence of the land.

(*e.*) That the great glacier period of New Zealand was in the Pleistocene, since when the glaciers have been gradually retreating and diminishing in size.

(*f.*) That the Pleistocene great extension of the glaciers was mainly caused by refrigeration due to elevation of the land rather than general climatic conditions.

(*g.*) That the distribution of the Oamaru and Waitotara series, ascending in height from the sea on both coasts towards the interior, is an evidence of differential elevation along the main orographic axis.

(*h.*) That the Pareora, Kakahu, Waihao, Black Point, and Hampden shell-beds belong to the Oamaru series.

(*i.*) That many areas mapped as Pareora are potential coal-bearing areas.

(*j.*) That the Motanau and Awatere beds overlie the Oamaru series unconformably, and belong to the Pliocene.

(*k.*) That the Oamaru series contains two distinct calcareous horizons—namely, the Waitaki Stone and Oamaru Stone,

which are separated by the Mount Brown or Hutchinson Quarry beds.

(*l.*) That the Weka Pass Stone has no relation to the Waitaki or Oamaru Stone, but is the closing member of the Waipara series in Canterbury.

(*m.*) That the Weka Pass Stone is always conformable to the Amuri limestone.

CLASSIFICATION OF NEW ZEALAND FORMATIONS.

The classification which my investigations in the past four years have led me to adopt is as follows:—

Tertiary ..	Recent ..	.. River and beach sands and gravels, sand-dunes, &c.
	Pleistocene ..	.. High-level gravel terraces, old moraines, old river-fans, &c.
	Newer Pliocene	.. Wanganui series.
	Older Pliocene	.. Te Aute or Waitotara series.
	Miocene ..	.. Oamaru series.
Secondary	Upper Cretaceous	.. Waipara series.
	Jurassic ..	.. Mataura series.
	Triassic ..	.. Shaw Bay series.
Primary ..	Permo-Carboniferous	.. Mount Mary series.
	Carboniferous	.. Kakanui series.
	Upper Silurian	.. Mount Arthur series.
	Lower Silurian	.. Collingwood series.
	Azoic ..	.. Crystalline schists of Otago.

ART. LVII.—*On the Occurrence of Large Bodies of Ferrous Sulphate in the Gold-mines of Thames Goldfield.*

By MATTHEW PAUL, Mine-manager.

Communicated by Professor James Park.

[*Read before the Otago Institute, 8th November, 1904.*]

SULPHATE of iron is found in large deposits in the old workings on the Thames Goldfields, principally in the Kuranui, Caledonian, Waiotahi, Victoria, and Moanataiari Mines, situated west or seaward of the Great Moanataiari Fault. In No. 3 level in the Kuranui-Caledonian Mine, in an old cross-cut drive (347 ft. from surface) which was driven for the purpose of connecting with the Waiotahi Mine some twenty-five years ago, there is a very large deposit of this mineral. In some parts it has almost filled this drive up, and one would think at first sight that the country-rock had fallen away, but on closer examination the whole of this is found to be sulphate of iron. In this level there is scarcely any moisture to be seen, and the deposit grows on the top,

bottom, and sides of the drive. It is very pale-green in colour, and when exposed to the atmosphere for some time gradually melts away, but if put under a glass case it keeps its form and colour for many years. At this particular level the mineral is very pleasing to the eye by candle-light, as nearly all the colours of the rainbow are reflected from its surface.

Ferrous sulphate also occurs at No. 1 level (210 ft.)—in one case the characteristics being somewhat similar to that already described, but in another place the reason for its formation can be plainly seen. The water dropping from the roof has formed stalactites of all shapes and size, some of them very beautiful in form and colour, many reaching from the top to the bottom of these old drives. The mineral is very brittle; and associated with it there is epsomite in large quantities, depending from the roof and sides of the drive in dense snow-white bundles like masses of fine-spun silk. The mineral filaments possess a silky lustre, and vary from 4 in. to 8 in. long.

In other parts of the mines there is a dark-green sulphate of iron, which is only found in drives where the reefs or veins have contained large quantities of iron-pyrites. The water dropping from the roof forms stalactites varying in size but not in colour. This variety is much harder than the former, and as brittle as glass.

There can be no doubt but that this formation is caused by the decomposition of iron-pyrites; and, although sulphate of iron is extensively used in the manufacture of manures, some of this sent for analysis was found to contain so much acid as to be of no commercial value.

Its composition is as follows: $FeSO_4 + 7\,H_2O$, equal to sulphur-trioxide 28·8, iron-protoxide 25·9, water 45·3, in 100 parts.

Art. LVIII.—*Notes on some Rocks from Campbell Island.*

By R. Speight, M.A. B.Sc.

[*Read before the Philosophical Institute of Canterbury.*]

These rocks were collected on Campbell Island by Mr. James Gordon, who forwarded them by Dr. Cockayne to the Canterbury Museum, with the object, I believe, of having them examined for gold. Campbell Island was formerly believed to contain mineral deposits, and whalers stated that tin was found there. Though there is no absolute impossibility that

such occurs, yet it seems highly unlikely that any payable deposit exists.

During the French expedition to the island in 1874 for the purpose of observing the transit of Venus, a careful study was made by members of the scientific staff, and no traces of any metallic ores were found. Perhaps the presence of iron-pyrites in small amount in one of the specimens has encouraged the hope that gold may occur. As I have not visited Campbell Island I have no personal knowledge of its geological structure; but an excellent account of it is given in Filhol's "Mission de l'Île Campbell," which I have found of much assistance. I have no knowledge of the field relations of the rocks under consideration.

No. 1.

This is a greyish-white rock, so much weathered that an accurate determination is difficult. The specific gravity is 2·56. To the eye it appears holocrystalline, with crystals of felspar plainly visible; some of these are 5 mm. in length. A brassy yellow mineral is also present, but I could not determine it for certain; it has, however, all the appearance of iron-pyrites. On treating the rock with acid there is a marked effervescence in every part, owing to the presence of calcite. The soft character of the rock makes it difficult to treat microscopically, but thin sections show plainly that it is holocrystalline, and composed principally of much-decomposed felspar. A large proportion of this is so weathered that it could not be determined accurately, but the lamellar twinning shows that some is certainly plagioclase. Whether it is all plagioclase I cannot say, but the occurrence of calcite in large quantity points to the presence of a basic felspar. It is possible that this may be partly due to infiltration from the limestone deposits which occur on the island. The calcite permeates the whole rock, and sometimes occurs in masses 1 cm. in length. There is also an amount of amorphous black matter which is no doubt due to the decomposition of the original ferro-magnesian mineral. I detected none in the slides, but the examination of crushed fragments showed small grains of a brown mineral which is perhaps hornblende.

The foregoing description shows the rock to be either a weathered syenite or diorite, most probably the latter. In the report of the Colonial Laboratory for the year 1903, page 10, there is the analysis of a Campbell Island diorite; but the percentage of CaO is too low for the rock under consideration, and the absence of CO_2 is a further proof that the two rocks are different. This may be due to the introduction of a vary-

ing amount of foreign matter into different portions of the rock-mass, and the two samples may have come from different parts of the same dyke or intrusion.

Campbell Island is formed of volcanic and sedimentary rocks of perhaps early Tertiary age, resting on a platform of metamorphic schists. The existence of granite dykes in these is recorded in Filhol's "Mission de l'Île Campbell," page 143, but no diorite dykes are mentioned. Such intrusive rocks might be expected to occur in the off islands of New Zealand, as they are not truly oceanic, but part of a continental area which stretched chiefly to the east and south, and which was above sea-level, either wholly or partly, during late Tertiary times.

No. 2.

This is a basic glass or tachylyte—specific gravity about 2·5, hardness 4–5, with a brown streak, fusibility about 3; the water-percentage I found to be 6·3. But the following analysis, taken from the report of the Colonial Laboratory for the year 1903, gives details of its chemical composition:—

Silica	54·1
Alumina	18·2
Iron-oxides	11·2
Lime	3·8
Magnesia	0·5
Manganese-oxide	0·1
Alkalies and undetermined	4·9
Water	7·2
	100·0

This analysis shows the usual characteristic of a basic glass—viz., the high percentage of silica; but it is probable that it may be the glassy equivalent of the andesites found on the island.

Microscopic examination shows that it is undoubtedly a glass, rendered almost opaque by magnetite-dust. This is aggregated at times into cumulous masses, which sometimes show radial arrangement, the intervening spaces being more translucent. Perlitic cracks, due to cooling, are common. Porphyritic crystals of plagioclase and augite of very small dimensions also occur very sparingly.

When placed near the pole of an electro-magnet almost all the powdered rock was strongly attracted, due, no doubt, to the excessive amount of magnetite-dust disseminated throughout it.

V.—PHYSICS.

Art. LIX.—*Meteorology of New Zealand: On the Routes of High and Low Pressures, and the Changes of Pressure and Wind-movement resulting from them.*

By Retired Commander R. A. Edwin, R.N., Weather Reporter.

[*Read before the Wellington Philosophical Society, 3rd August, 1904.*]

In describing the changes of both pressure and wind which occur in this colony it is first of all necessary to describe the principles upon which the atmospheric movements which bring about these changes are carried out.

There are two divisions of atmospheric pressure—viz., high and low. The former are termed "anticyclones," and consist of separate systems which are generally of an irregularly shaped circular, and sometimes of elliptical, form, and within which pressure is always above 30 in., increasing concentrically inward to a maximum point. Their progression is always from west to east, and in this hemisphere their wind-rotation is from right to left, or as against the hands of a watch.

Low pressures are all systems having pressure below 30 in., and are of two kinds: (1.) Cyclonic, in which pressure is considered to be arranged spirally, and decreasing to a central minimum area. In these low pressures the wind is also considered as being arranged spirally, and in this hemisphere both move from left to right, or similarly to the movement of watch-hands. They originate within the Tropic of Capricorn, between the Equator and about 8° of south latitude, and their route is first toward a little southward of west, curving towards south-west and south, and finally to south-east. (2.) Westerly low pressures, in the form of waves, in which pressure is oscillatory, and is in this hemisphere always lowest towards the Pole. Their winds are also oscillatory, ranging from the north through west towards south, and back through the west towards north. Neither wind nor pressure has any definite period of duration, but their changes are regular, pressure always diminishing when the wind moves from the north towards west, and increasing with winds between west and south. The movement back to north is often accomplished so quickly that pressure seems to be increasing also during that time.

The wind and pressure movements of an anticyclone of this hemisphere are illustrated by fig. 1, which shows these changes as the high pressure moves from west towards east over three positions, *a*, *b*, and *c*, considered as being situated

in a north and south line, and at a distance of about two hundred miles apart. The progressive eastward movement of the whole system is indicated by the compression of the lines on its eastern or advancing side. Each circle represents $\frac{2}{10}$ in. of pressure, or from 30 to 30·4. The small arrows show wind-rotation and the large feathered arrow the forward movement.

ANTICYCLONE (SOUTHERN HEMISPHERE).

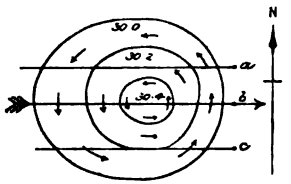


Fig 1.

It will be seen that at *a* pressure increases from 30 in. to about 30·3 in., the wind changing from the southward toward east, and that when the maximum pressure has passed to the right of—*i.e.*, to the eastward of—*a*, but also lies to the southward of it, pressure decreases to 30 in., with the wind changing to north-east; at *b* pressure increases to 30·4 in., the wind continuing in the south, because the position of *b* is such that it lies directly in the route of the anticyclone maximum pressure, and when this has passed to the eastward of *b* the wind comes from north and pressure decreases to 30 in., but at *c* pressure increases only about $\frac{2}{10}$ in. or to 30·2 in., with south-west wind changing toward west; and as the maximum pressure passes to the eastward of *c*, but lies also to the northward of it, pressure decreases to 30 in., with wind changing to the north-west. It will be seen by this figure that, although the wind-rotation of the whole system is from right to left, the changes in the direction of the wind as experienced at *a* and *c* are in quite opposite directions.

Nearly all anticyclones have more than one maximum area. This is shown by the occurrence of partial decreases of pressure, accompanied by changes of wind to the northward, and similar to that which has been shown to occur when a high pressure passes away and is followed by partial increases, accompanied by southerly wind, corresponding to those shown as taking place on the first approach of high pressure. Diagram No. 2 shows an anticyclonic pressure curve of the Southern Hemisphere containing three maximum points: at *d* pressure is at 30 in., with southerly winds, and increases to *e*; then decreases with northerly winds to *f*, followed by a second increase and southerly winds to *g*; then decreases with northerly winds to *k*, and increases with southerly winds to *m*, finally decreasing with northerly winds to 30 in.

ANTICYCLONE HAVING THREE MAXIMA (SOUTHERN HEMISPHERE).

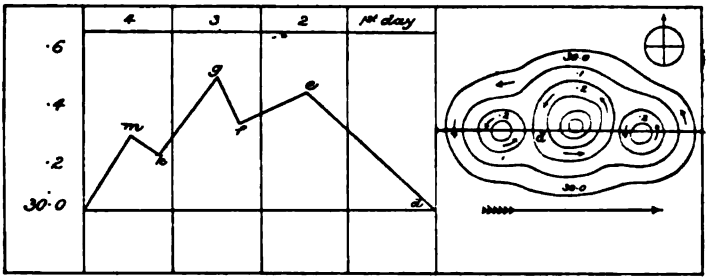


Fig 2.

In this country anticyclonic pressure is not usually disturbed northward of the latitude of East Cape: it frequently extends southward to the latitude of Hokitika, and, though not unusual further south, it is generally of shorter duration than in other parts of the country. While high pressure is likely to continue the sunset colours are always in the west, and indicative of fine weather; but when a westerly low-pressure wave is approaching the sunset colours become prominent in the east. Sometimes, when pressure is above 30·3, a most remarkable cumulus cloud forms in the eastern sky, having three or four very lofty summits composed of closely packed globular masses, which towards the base are of great size, decreasing upward until the topmost ones are very small. The cloud-base is heavy, compact, and of an undulating form, with edges of a whitish colour. All portions of the cloud are in continual movement, and the upper parts are of all shades of delicate greys, but the base is of deep bluish-black or neutral tint. When the summits are lit up with sunset tints, while the base remains dark, the whole cloud has a very beautiful but threatening appearance. Strong northerly winds set in soon after the cloud forms, and soon increase to a heavy gale, pressure decreasing slowly until at about 30 in., soon after which it falls rapidly, with wind moderating, and the cloud passing away to the eastward.

WAVE-PRESSURES.

Following anticyclone pressures there are usually these low pressures from the west; their wind-movement is from the north-north-east or north towards west, with decreasing pressure as the first minimum or wave approaches; but increasing and the wind changing from the west toward south as it passes to the eastward, the wind then changing back through the west to north or north-north-east, and pressure again decreasing with the advance of the next minimum. These oscillations of both wind and pressure continue for uncertain periods, but are ultimately succeeded by anticyclonic pressure.

Fig. 3 shows a short series of these waves with preceding and following high pressures. Each vertical space represents one day; each pressure-line represents $\frac{2}{10}$ in.; the small arrows show the wind-movement, and the long feathered arrow indicates the movement of all these pressures from west to east.

WAVE-PRESSURES (SOUTHERN HEMISPHERE).

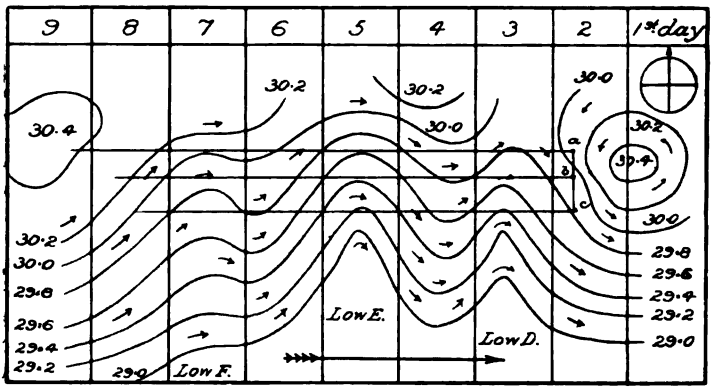


Fig 3.

Using the same positions as in fig. 1, the rear or left-hand side of the anticyclone is shown as now being indented by the advancing depression D, and as this progresses eastward the wind at *a* changes to the north-west, pressure continuing to decrease slowly until a little below 29·80, when the wind comes from the west; but at *b* the decrease is to 29·60, also with north-west changing to west, while at *c* pressure falls to 29·35 with the same wind-movement. As D passes to the right or eastward pressure increases with wind from the south-west at all three stations—*a* to 30 in., *b* to 29·80, *c* to about 29·65. This change of wind—*i.e.*, back to west from the south-west, or from left to right—is the reverse of that which precedes it, and, as E is now approaching, this backing movement is continued further towards the north at each position; it causes a second decrease of pressure which at *a* falls to about 29·70, at *b* to about 29·45, and at *c* to about 29·10. The wind-movement has now been from right to left at all three places, and south-west winds with rising pressure occur again as E continues its easterly movement, the change at *a* being an increase to about 30, showing that this place is now within anticyclonic pressure; but *b* and *c* remain within low-pressure limits, the increase being at *b* to 29·90, *c* to 29·80, with the wind back again to west. The approach of F causes pressure to decrease again with

wind-movement from right to left, but F is of less energy than its predecessor. This is shown by the curves being easier and wider apart; and, though the changes of wind are of the same character as before at each place, they are of less force, there being but very little pressure-movement at *a*, but *b* falls to 29·80, and *c* to 29·70. The easterly progress of F brings south-west winds, with increasing pressure, but as an anticyclonic system is now approaching the wind remains about south-west, and pressure continues to increase, at *a* and *b* to 30·30, at *c* to 30·25. *a* has now been in high pressure ever since E passed to the eastward of it, and the continuance of the south-west winds at each position shows that the maximum pressure of the second anticyclone passes to the northward of them all.

The following table shows the alterations of pressure at each station (+ showing increase, − showing decrease):—

REGISTER OF PRESSURE-MOVEMENTS, SOUTHERN HEMISPHERE (FIGS. 1 AND 3).

Station.	Fig. 1: Anticyclone		Westerly Wave Low Pressures: Fig. 3.						Fig 3: Anti-cyclone.
			D.		E.		F.		
	Approaching.	Passed.	Approaching.	Passed.	Approaching.	Passed.	Approaching.	Passed.	Approaching.
a	+0·30	−0·30	−0·25	+0·20	−0·30	+0·30	Steady	Steady	+0·40
b	+0·40	−0·40	−0·40	+0·20	−0·36	+0·46	−0·10	+0·10	+0·60
c	+0·20	−0·20	−0·65	+0·30	−0·50	+0·70	−0·10	+0·10	+0·60

ANTICYCLONIC AND WESTERLY WAVE-PRESSURE CURVES (SOUTHERN HEMISPHERE).

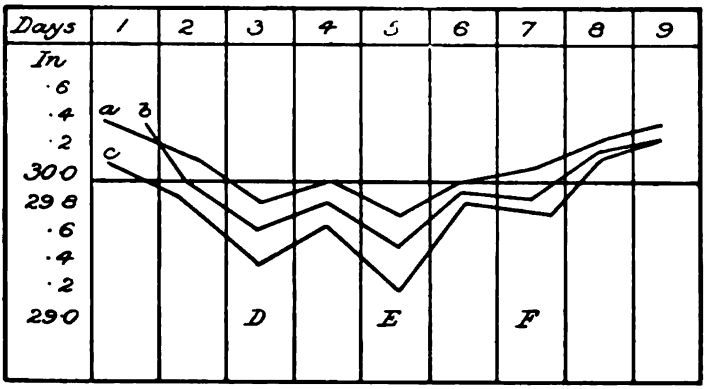


Fig 4.

With the departure of the second anticyclone follow changes somewhat similar to those just described, but varying according to the energies of the succeeding disturbances so long as anticyclonic and wave-pressures follow each other.

The lowest pressures of these waves always pass to the southward of this country: they usually include within their limits all parts of it lying to the southward of East Cape and Raglan, but some are of much greater area, and extend northward to the Three Kings Islands, and sometimes to Norfolk Island. These low-pressure waves occupy on an average six days from the date of their passing the meridian of Cape Leeuwin to the meridian of the South Cape of New Zealand.

The upper and intermediate clouds which precede and accompany westerly wave-pressures are cirrus, cirro-stratus, and cirro-cumulus. They are generally first seen in the west, and travel towards east, changing from west towards north-west—*i.e.*, from left to right—as pressure decreases, and from north-west to west, or from right to left, before it increases, alternating in this manner with the passage of each westerly wave, but finally continuing the right-to-left movement towards south-west and south with the rising barometer as anticyclonic pressure approaches. When cirrus clouds have their tips curled back towards the direction they come from, or increase quickly, and are moving fast, high winds generally follow soon; and when they are seen coming from between north-west and north they usually indicate a wave-pressure of greater than ordinary extent. Alto-cumulus clouds come from between west and south, and generally precede anticyclonic pressure. Solar and lunar coronæ, and also imperfect halos, are seen with these disturbances. With westerly wave-pressures there is usually seen in the eastern sky at sunset a well-defined pink or rose colour, whose upper edge gradually pales into the blue above it, but very little and sometimes none of the ordinary sunset tints are seen in the west; the rose colour sometimes deepens most distinctly for a minute or two, then moving upward fades quickly and disappears; it is succeeded by a pale yellowish colour, above which there is frequently a pale green, and patches of pale orange are seen low down toward the south.

Cyclones.

Cyclones are easiest described as being low pressures of a bluntly oval shape much compressed on the line of advance, and having their pressure always decreasing inward to a central minimum of an almost circular shape. Their wind-rotation in this hemisphere is from left to right, or in accordance with the movements of the hands of a watch. Fig. 5 shows the wind and pressure changes caused by the eastward

movement of an anticyclone, followed by a cyclone from a north-westerly direction. Each vertical space represents one day. Each oval shows a decrease of two-tenths pressure toward the central one. The small arrows indicate the wind-rotation; the long feathered arrow on the left shows that the cyclone is travelling towards south-east, and the one on the right that the anticyclone is progressing eastwards. The left-hand side or rear part of the high pressure is shown slightly indented as the effect of the approaching cyclone, whose front curves are compacted in the line of its advance.

CYCLONE AND ANTICYCLONE (SOUTHERN HEMISPHERE).

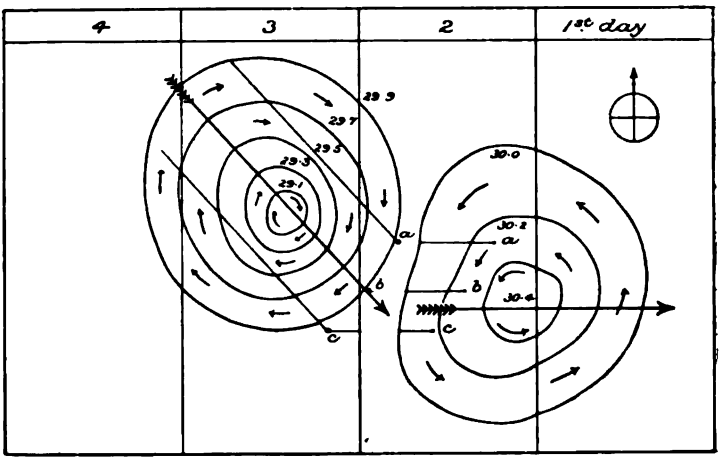


Fig 5

Using three positions—viz., *a*, *b*, and *c*—situated upon a line from north-east to south-west, the diagram shows that the movement of the high pressure to the eastward has caused a decrease of pressure accompanied by northerly winds at each station, and that as the cyclone approaches pressure continues to decrease, and has at *a* fallen to 29·90, wind about north-north-east; at *b* to 29·85, wind north-north-east; and at *c* to 29·90, wind north-east. The continued advance of the cyclone causes further changes; at *a* the decrease is to 29·60, wind north-west; at *c* the wind has changed from north-east through east to south-east, and pressure has fallen to 29·40. The minimum pressure of the cyclone is now at its nearest to both of these positions, but at *b*, which lies directly in the track of the cyclone centre, pressure has fallen rapidly to 29·05, and the wind, which remained at about north-east, varies rapidly from all directions while the centre is passing over *b*, finally steadying in the south-

west. The continued progress of the cyclone to the south-east brings about the following changes: At *a* pressure increases to 29·65, with wind about west-north-west; at *b* to 29·50, wind south-west; at *c* to 29·60, wind about south-south-west; and finally pressure increases to 29·90 at all three stations, with westerly winds. The wind-changes at *b* and *c* have been shown to be in accordance with cyclonic wind-rotation, but at *a* it has changed in the contrary way. Figs. 1 and 3 show that the changes of wind-direction within anticyclonic or cyclonic systems depend upon the position of the observer with reference to the storm-track.

The following table shows the changes of pressure at each station (+ showing increase, − showing decrease):—

REGISTER OF PRESSURE-MOVEMENT (FIG. 6), (SOUTHERN HEMISPHERE).

Station.	Anticyclone.	Cyclone.	
	Passing.	Approaching.	Passed.
a	− 0·30	− 0·60	+ 0·40
b	− 0·40	− 0·95	+ 0·95
c	− 0·40	− 0·60	+ 0·40

ANTICYCLONE AND CYCLONE PRESSURE CURVES AT *a*, *b*, AND *c* (SOUTHERN HEMISPHERE).

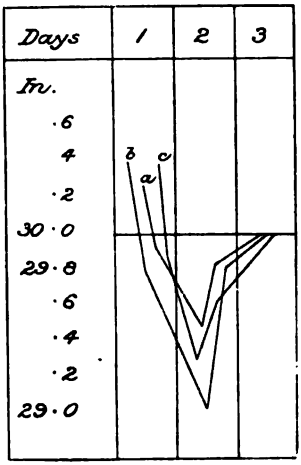
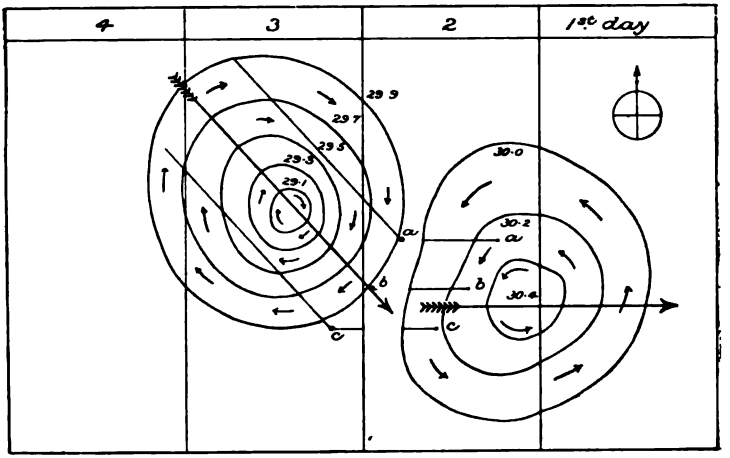


Fig 6

Cyclones approach this country from the north-westward, but this route does not always lead them to the same part of

movement of an anticyclone, followed by a cyclone from a north-westerly direction. Each vertical space represents one day. Each oval shows a decrease of two-tenths pressure toward the central one. The small arrows indicate the wind-rotation; the long feathered arrow on the left shows that the cyclone is travelling towards south-east, and the one on the right that the anticyclone is progressing eastwards. The left-hand side or rear part of the high pressure is shown slightly indented as the effect of the approaching cyclone, whose front curves are compacted in the line of its advance.

CYCLONE AND ANTICYCLONE (SOUTHERN HEMISPHERE).



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Using three positions—viz., *a*, *b*, and *c*—situated upon a line from north-east to south-west, the diagram shows that the movement of the high pressure to the eastward has caused a decrease of pressure accompanied by northerly winds at each station, and that as the cyclone approaches pressure continues to decrease, and has at *a* fallen to 29·90, wind about north-north-east; at *b* to 29·85, wind north-north-east; and at *c* to 29·90, wind north-east. The continued advance of the cyclone causes further changes; at *a* the decrease is to 29·60, wind north-west; at *c* the wind has changed from north-east through east to south-east, and pressure has fallen to 29·40. The minimum pressure of the cyclone is now at its nearest to both of these positions, but at *b*, which lies directly in the track of the cyclone centre, pressure has fallen rapidly to 29·05, and the wind, which remained at about north-east, varies rapidly from all directions while the centre is passing over *b*, finally steadying in the south-

Anticyclones, Cyclones, and Westerly Wave-pressures have now been described, but none of them have any definite period of occurrence or of duration. All are continually undergoing some process of change, increasing or decreasing both in energy and area. All have their special arrangement of wind-movement, which, though constant to each, is subject to great deflection by the contours of the land and by the action of one system upon another. All have definite but different routes, to which they keep unless deflected from them by a system of different kind and greater energy, and there is no definite period of alternation between high and low pressures.

The Probable Mechanical Principle on which Atmospheric Circulation is based.

Meteorological investigations have enabled us to define certain systems of pressure, their wind-movements and routes, and from these it may be possible to deduce some further information as to the nature of the principles which guide the movements of our atmosphere.

Lying adjacent to and on both sides of the Equator are high-pressure systems which form two complete belts round the globe. Their wind-rotations are in opposite directions: those north of the Equator have this movement from right to left, but in those southward of it the rotation is from left to right. In each belt there are many systems, each generally of great extent, but all separate from each other. Their route on both sides of the Equator is from west to east, but none complete the circuit of the earth. Between these high-pressure belts lies the Equatorial belt of low pressure, and the latitudinal limits of the high pressures vary from the northern and southern limits of the Equatorial belt to from 30° to 50° of north and south latitude. Within these limits the high pressures are always undergoing changes—expanding, contracting, or merging into one another. To these changes the Equatorial belt moves sympathetically, and it is therefore irregular in width and sinuous in outline.

Consideration of these atmospheric conditions discloses a mechanical arrangement in which the anticyclones composing each belt correspond to the movements of a series of circular discs revolving in opposite directions, and having between them a belt upon which they press equally. The revolution of the discs causes the belt to move from right to left—*i.e.*, from east to west; or, if we consider the belt as being the motive power coming from the right, then the bodily movement of the discs must be to the right, or from west to east, and their rotation must correspond with the wind-rotation of the anticyclonic systems of each hemisphere, while the

movement of the belt shows that the wind-currents of the Equatorial low pressure must mainly travel from the eastward. The mechanical movement is continued on the polar side of both the high-pressure systems by belts of westerly winds which extend round the earth; but, owing to the continual changes in the dimensions of the high pressures, these belts of westerly winds are of varying width and sinuous form, causing deflection of the westerly current to between south-west and north-west in the Northern Hemisphere, and to between north-west and south-west in the Southern Hemisphere, resulting in wavelike depressions whose route is towards east. Pressure within both of these belts decreases polewards, and their latitudinal limits extend from the edges of the anticyclonic belts to between the 60th and 70th degrees of both north and south latitudes.

Cyclones originate within the limits of the Equatorial belt, and in both hemispheres travel first towards the west, those of the Northern Hemisphere curving gradually toward north and east, those of the Southern Hemisphere toward south and east. Some of these disturbances have sufficient energy to force their way between the systems of the anticyclone belts and into the regions of the westerly winds, to which they convey both heat and moisture.

Continuing the consideration of mechanical effort, it is evident that the rotation of the two discs is such that the movement of their poleward edges is towards the right—*i.e.*, to the eastward—therefore a belt resting on these edges must move parallel to them, and to this movement the west-wind belts correspond.

On the northern side of the west-wind belt of the Northern Hemisphere, and on the southern side of that of the Southern Hemisphere, pressure is lower than in all other regions, and therefore it should seem that there should be continuous westerly winds circulating round a minimum pressure at each pole. But it is well known that easterly winds are experienced in very high latitudes, and from this it is evident that some other arrangement of winds and pressure exists within these areas. Further consideration of the mechanical effort already mentioned will show that the movement of the west-wind belts must influence whatever pressures lie poleward of them, and that their action on a disc lying between them and the pole would be to cause the disc to rotate from right to left—*i.e.*, from west to east—and therefore the edge nearest the pole must move from east to west. This rotation corresponds to the wind-revolution of the anticyclone of the opposite hemisphere, and must be accompanied by an increase of pressure toward the centre of the disc, although pressure within that area is low.

The atmospheric circulation of both Poles should therefore be principally anticyclonic, but with lower pressure than in other parts of the world, and consists of a series of anticyclones having progressive movement towards east, their limits poleward being in very high latitudes, probably to between 85° and 87°.

But there are other easterly winds which, though they may not occur frequently, have been experienced in high latitudes within which westerly winds predominate—*i.e.*, on the poleward edges of both west-wind belts—and they therefore do not belong to any system of anticyclonic winds. Now, precisely the same effect—viz., easterly winds in west-wind regions—is produced in temperate latitudes when a cyclone from equatorial latitudes has advanced sufficiently far to carry its easterly winds into the west-wind belt.

There thus seems probability that there are low pressures within both Arctic and Antarctic Circles, and if so their wind-rotation must be cyclonic, and corresponding to that of the cyclone of the opposite hemisphere, the area within which they originate being near the Poles—arctic cyclones travelling first from the Pole toward west, then curving towards south and south-east; antarctic cyclones travelling from the Pole toward west, curving toward north and north-east. These low pressures would convey cold and moisture, as snow, into the west-wind belts, but though cold they would be warmer than the anticyclonic systems of either Pole. Between the poleward edges of the anticyclones and the Poles there should be variable winds.

If the mechanical principle upon which the horizontal circulation of the atmosphere is arranged be such as has now been described, then the corresponding vertical movement should be that all anticyclonic systems are descending currents, and all others are ascending currents.

The governing principle regulating Horizontal atmospheric circulation may be described as being that which controls the movements of three belts placed alternately between four circular discs, which press upon them sufficiently to insure friction, as in fig. 7, in which it is evident that if the central belt be pulled toward the left-hand side of the figure all the other belts and discs must move in accordance.

The governing principle of Vertical atmospheric movement should be that which controls the uptake and downcomer circulation of the multitubular boiler.

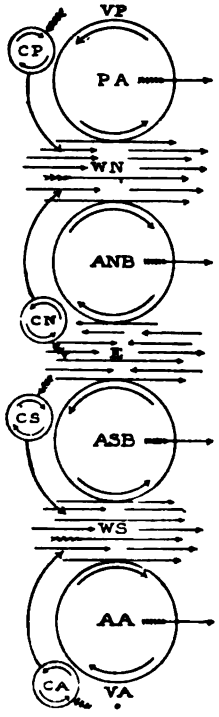
The influence of the sun upon the whole atmosphere is to cause all its systems to move southward from the time he has attained to his maximum north declination until he has reached his maximum south declination, from which

time the movement is back again northwards. These changes follow the date of the change of declination. Temperature decreases in all northern systems during the southward movement, but increases in all the southern systems, the reverse taking place with the northward movement.

The demands of life, land, and water are enormous, constant, and imperative, and therefore there must be continual changes in atmospheric conditions near the earth's surface, necessitating constant renewal.

THE THEORY OF THE MECHANICAL PRINCIPLE OF ATMOSPHERIC CIRCULATION.

Fig. 7



VP. Variable polar winds. PA. Anticyclones of Arctic region. CP. Cyclones of Arctic region. W. West-wind belt of Northern Hemisphere. ANB. Anticyclones of northern belt. CN. Cyclones of Northern Hemisphere. E. Equatorial belt of low pressure. ASB. Anticyclones of southern belt. CS. Cyclones of Southern Hemisphere. W. West-wind belt of Southern Hemisphere. AA. Antiocyclones of Antarctic region. CA. Cyclones of Antarctic region. VA. Variable winds of South Pole.

Feathered arrows show routes, all of which are eastward. Unfeathered arrows show wind-movements.

Art. LX. — *The Distillation of the Fatty Acids for the Manufacture of Candles.*

By P. W. Robertson, B.A., Senior Scholar.

[*Read before the Wellington Philosophical Society, 6th July, 1904.*]

Many processes have been suggested for the preparation of the fatty acids from tallow. Of these, the only one practised in New Zealand is that in which the tallow is hydrolised by means of a small quantity of sulphuric acid. The acids thus obtained are washed free from the sulphuric acid and glycerine, and then distilled in superheated steam.

The products of the distillation have been investigated by Cahours, who paid attention to the volatile portions of the distillate, consisting essentially of a number of the lower fatty acids. The object of the present investigation was to examine the course of the distillation from a physico-chemical standpoint, and no attention was paid to the volatile by-products.

Only in one factory in New Zealand is the distillation conducted in a copper retort, and in this case, as soon as the charge begins to become yellow it is blown into an iron retort, in which, after four or five charges have been collected, the distillation is concluded. In the factory* where the experiments were conducted the whole charge is distilled from an iron retort; the last portions, being too soft and discoloured for candle-making, are returned to the retort and distilled with the next charge. The fatty acids condense in a number of coils, the first three of which collect practically the whole of the distillate.

The freezing-point is a most important property to the candle-manufacturer, as the magnitude of this constant gives a direct measure of the hardness of the material, and hence its suitability for candle-making. Consequently, these data were studied in great detail. At the outset it was found that it would be much better to ascertain the temperature of freezing rather than the melting point, for in the latter case definite results could not always be obtained: hence in the whole operation the freezing-points were determined. To make the observation the bulb of the thermometer was placed in the melted sample, and then held in a small beaker to avoid the influence of air-currents. The mean of two or three determinations was taken as the final result.

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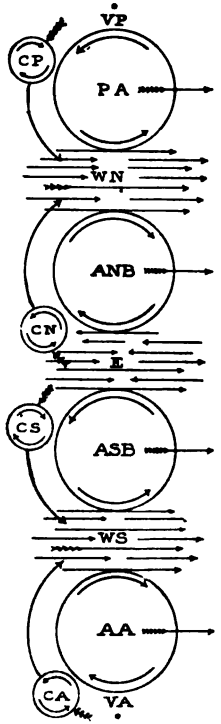

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The values thus obtained are given in Table I., and are plotted against the time in figs. 1, 2, and 3.

TABLE I.

Series 1.

Time.	First Coil.	Second Coil.	Third Coil.
9 a.m. ...	42·6	...	...
9.45 a.m. ...	42·2	42·4	...
10.30 a.m. ...	42·6	42·6	42·8
11 a.m. ...	42·8	42·8	42·8
11.30 a.m. ...	43·2	43·0	43·0
12 noon ...	44·0	43·4	43·0
12.30 p.m. ...	44·6	44·0	43·2
1 p.m. ...	46·0	45·0	44·0
1.30 p.m. ...	46·4	45·6	45·0
2 p.m. ...	46·6	45·8	45·4
2.15 p.m. ...	44·4	45·6	45·4
2.30 p.m. ...	42·2	...	...
2.45 p.m. ...	46·4	...	...

Series 2.

2.5 p.m. ...	46·0	46·0	...
2.15 p.m. ...	44·0	45·5	...
2.25 p.m. ...	45·5	45·0	...
2.35 p.m. ...	46·5	44·0	...
2.42 p.m. ...	47·5	43·0	...

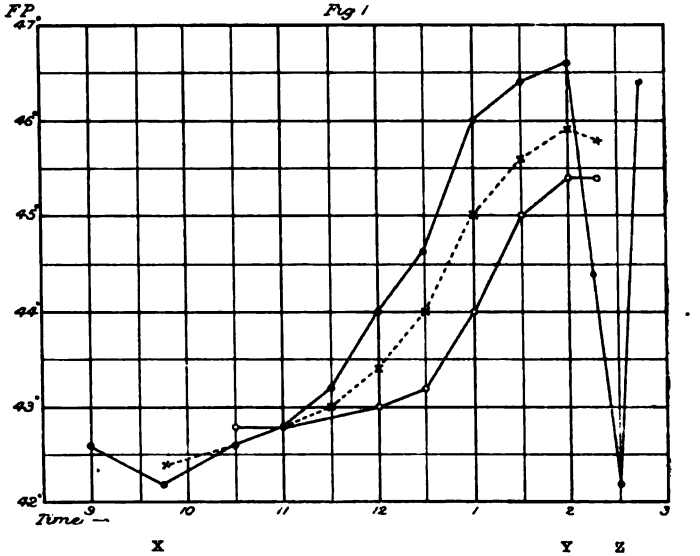
Series 3.

2.25 p.m. ...	45·0	44·5	...
2.32 p.m. ...	45·5	44·0	...
2.40 p.m. ...	44·5	42·5	...
2.50 p.m. ...	44·0	42·0	...
2.57 p.m. ...	43·0	41·5	...
2.63 p.m. ...	41·0	41·5	...

In series 1 are the complete results for the products from three coils during the whole distillation. In series 2 and 3 only the last portions were examined, but in much greater detail.

It can hardly be expected to obtain similar results in three instances, as the composition of the original charge, the temperature of the distillation, and the rate are all liable to vary. Each distillation, however, was performed with a medium charge—that is, one obtained from about equal amounts of hard and soft tallow. But in series 1 the temperature must have been higher, and the distillation conducted more rapidly towards the end, as the final portions contain a large portion of the products of decomposition. The second distillation

corresponded with the first, although the decomposition in this case is not so great. In the third series the temperature was lower and the operation conducted more slowly. Further, the charge, though medium, was somewhat softer, containing less stearic acid and more palmitic and oleic acid.

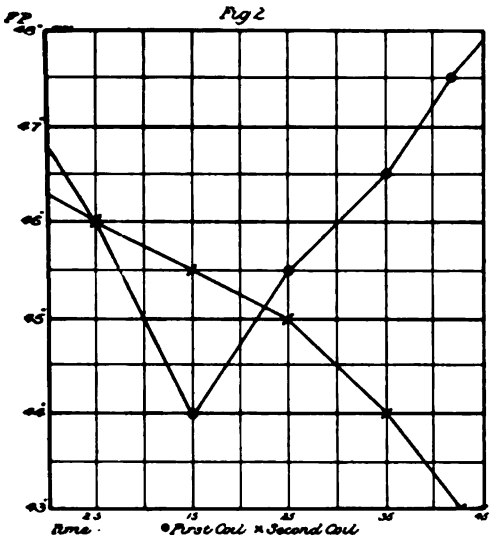


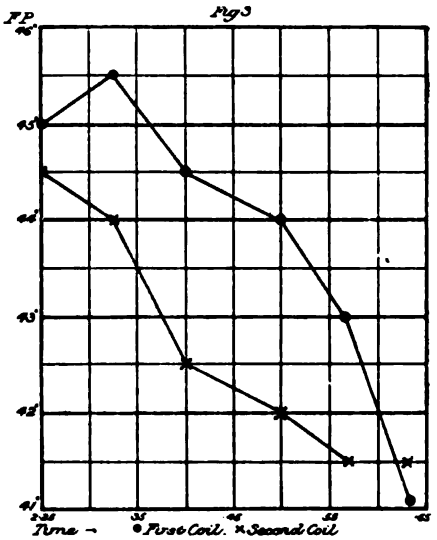
From a consideration of the three series of experiments the following conclusions can be drawn: In the case of the runnings from the first coil the freezing-point first falls a little and then rises more and more rapidly until it reaches a maximum just before the end of the operation. After that there is a very rapid fall, followed by an even more rapid rise. This final rise, however, is not noticeable in the third series of experiments, but in this case the charge was softer and the temperature was not allowed to rise so high.

During the early stages of distillation the freezing-points of the product that condenses in the second coil are slightly higher than those of the runnings through the first coil. However, the curves soon cross, and then keep parallel for most of their length; but whereas the first curve falls rapidly, the second suffers only a slight decrease, crossing the first as it is falling and again during its rise (fig. 2). The third curve commences higher than the second, but falls below it just as the second gradually drops below the first.

A complete investigation of this nature does not appear to have been previously made, and the exact nature of the changes have not been studied. By testing with his thumb

the distiller knows that the product is at first soft. It then opens out and becomes harder and harder. Towards the end





of the operation it becomes brown in colour, and begins to soften once more.

It is generally stated that the freezing-point gradually rises and then falls rapidly. The initial fall and the final rise appear to have been unnoticed by former observers. Further, the results obtained from the different coils are of distinct interest, and in fact have been found to be of great assistance in understanding the nature of the changes that occur. However, a complete analysis was necessary to ascertain the variation of the composition of the products obtained throughout the investigation. The different samples were analysed by means of the following methods:—

The *oleic acid* was estimated by finding the amount of iodine absorbed according to the method of Hübl. The iodine-solution was made by dissolving 25 grams of iodine and 30 grams of mercuric chloride in 95 per cent. alcohol. This was standardised against N/10 sodium-thiosulphate solution, the strength of which was known accurately by comparison with deci-normal potassium-bichromate.

About 1 gram of the substance to be analysed was dissolved in 10 c.c. of chloroform and transferred to a large stoppered bottle. 25 c.c. of the iodine-solution was run in and the mixture was left, with occasional shaking, for two hours. At the end of that time 20 c.c. of 10-per-cent. potas-

sium-iodide solution and 400 c.c. of water were added. The excess of iodine was then determined by means of the sodium-thiosulphate. The oleic acid was thus determined by difference.

The experimental results are given in Table II. It is seen that the percentage of oleic acid rapidly rises but finally becomes almost constant. More detailed experiments (series 2) show that after the maximum has been reached there is a slight fall, but at the extreme end of the operation the amount again increases.

TABLE II.—OLEIC ACID.

Time.	Coil.	Weight.	c.c. N/10.	Wt. Oleic.	%
Distillation, May, 1903.					
10 a.m.	1	0·1044	27·1	0·382	36·6
		0·1450	36·9	0·520	36·9
12 noon...	1	0·980	29·6	0·416	42·5
		1·051	31·4	0·443	42·3
1.15 p.m.	1	1·052	35·2	0·496	47·2
2 p.m.	1	1·067	37·0	0·475	49·0
2.30 p.m.	1	1·064	37·0	0·475	49·2
2.45 p.m.	1	1·052	35·4	0·496	47·5
10 a.m. ...	2	0·950	24·2	0·341	35·9
12 a.m. ...	2	0·995	29·7	0·417	41·9
Distillation, July, 1903.					
2.5 p.m. ...	1	0·948	33·8	0·477	50·3
2.15 p.m.	1	0·944	33·5	0·473	50·1
2.25 p.m.	1	0·946	33·7	0·476	50·3
2.35 p.m.	1	0·943	33·8	0·477	50·6
2.42 p.m.	1	0·952	34·4	0·485	51·0
2.5 p.m....	2	0·760	27·7	0·391	51·4
2.15 p.m.	2	0·746	27·1	0·382	51·2
2.25 p.m.	2	0·399	14·4	0·203	50·9
2.35 p.m.	2	0·400	14·55	0·205	51·2
2.42 p.m.	2	0·400	14·65	0·206	51·6

The *total acid* was determined by titrating with N/20 soda in alcoholic solution, using phenolphthalein as the indicator. It was found convenient to standardise the alkali against pure stearic acid under exactly the same conditions. The amount of oleic acid is already known, and from the relations—

1 c.c. N/20 soda = 0·128 gram palmitic acid,
= 0·141 „ oleic acid,
= 0·142 „ stearic acid,

the amounts of palmitic and stearic acids could be calculated indirectly. When the result is greater than 0·142, then the

excess is caused by the presence of non-acid decomposition products. Thus, in a weight W. if O be the amount of oleic acid and T total acid, then T − O = saturated acid; W − T = non-acid portion.

When W = T, then W = O + P + S, where P and S are the amounts of palmitic and stearic acid respectively.

The experimental numbers are given in Table III. Calculating from these results the amounts of the different constituents, it is possible to determine the ultimate composition of the various fractions. The results thus obtained are presented in Table IV.

TABLE III.—ACID VALUES.

Time.	Coil.	Weight.	c.c. N/20 Soda.	Equivalent of 1 c.c.
	Series 1.			
10 a.m.	1	3·860	28·8	0·134
12 noon	1	2·006	28·8	0·138
1.15 p.m.	1	1·950	13·9	0·140
2 p.m.	1	1·951	13·4	0·146
2.30 p.m.	1	2·116	11·4	0·185
2.45 p.m.	1	2·451	11·4	0·215
	Series 2.			
2.5 p.m.	1	1·188	8·3	0·144
2.15 p.m.	1	1·964	12·3	0·159
2.25 p.m.	1	1·977	12·0	0·165
2.35 p.m.	1	1·052	6·25	0·169
2.42 p.m.	1	1·948	11·4	0·172
2.5 p.m.	2	2·064	14·5	0·143
2.15 p.m.	2	2·085	13·8	0·151
2.25 p.m.	2	1·446	9·25	0·156
2.35 p.m.	2	1·456	9·05	0·161
2.42 p.m.	2	1·506	9·05	0·166

TABLE IV.

Series 1.

First Coil.

	Time.					
	10.	12.	1.15.	2.	2.30.	2.45.
Oleic acid	38	45	50	52	52	15
Palmitic acid	50	30	15	5	0	0
Stearic acid	12	25	35	40	25	17
Stearone and hydrocarbon ..	..	..	..	3	23	33
	100	100	100	100	100	100

Series 2.

First Coil.

—	Time.				
	2.5.	2.15.	2.25.	2.35.	2.45.
Oleic acid	50·3	50·1	50·3	50·6	51·0
Stearic acid	48·3	39·2	35·8	33·5	31·6
Stearone and hydrocarbon ..	1·4	10·7	13·9	15·9	17·4
	100	100	100	100	100

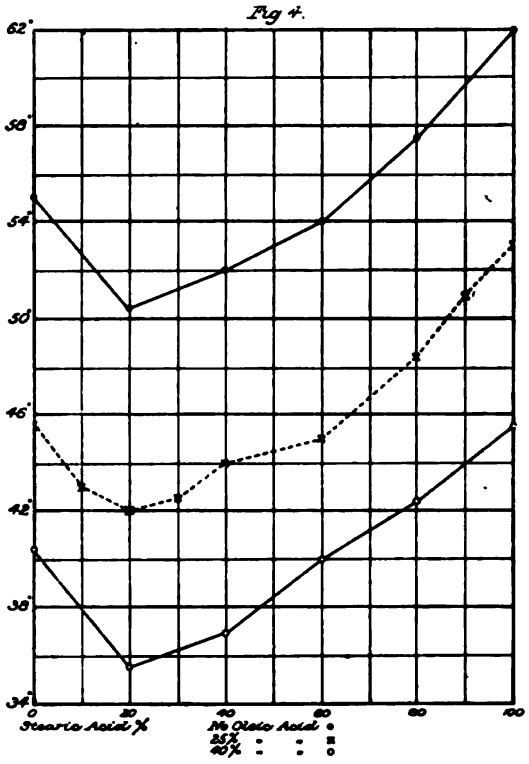
Second Coil.

—	Time.				
	2.5.	2.15.	2.25.	2.35.	2.45.
Oleic acid	51·4	51·2	50·9	51·2	51·6
Stearic acid	47·9	42·2	40·1	37·0	33·9
Stearone and hydrocarbon ..	0·7	6·6	9·0	11·8	14·5
	100	100	100	100	100

Having thus ascertained the composition of the various fractions, the freezing-point curve can now be considered. At the point X, where the first minimum occurs, the palmitic and stearic acids are in the proportion of 4 to 1. (See fig. 1.) Now, when the pure compounds are mixed in these proportions a eutectic mixture is formed. On adding a fixed quantity of oleic acid to palmitic and stearic acids, it was found that the composition of the eutectic mixture was not altered. Consequently, as the percentage of oleic acid in the neighbourhood of X varies only to a slight extent, the minimum observed in the freezing-point curve must be due to the formation of a eutectic mixture between the palmitic and stearic acids.

The following are the details of the experiments performed to prove this conclusion: Definite mixtures of pure palmitic and stearic acids were taken, and the freezing-points were determined. These results are represented in fig. 4. 25 per cent. of oleic acid was then added, and another series of freezing-point determinations was made. This formed a second curve. By employing 40 per cent. of oleic acid a third curve was obtained, and this was found to be approximately parallel to the other two. Further than this, the eutectic

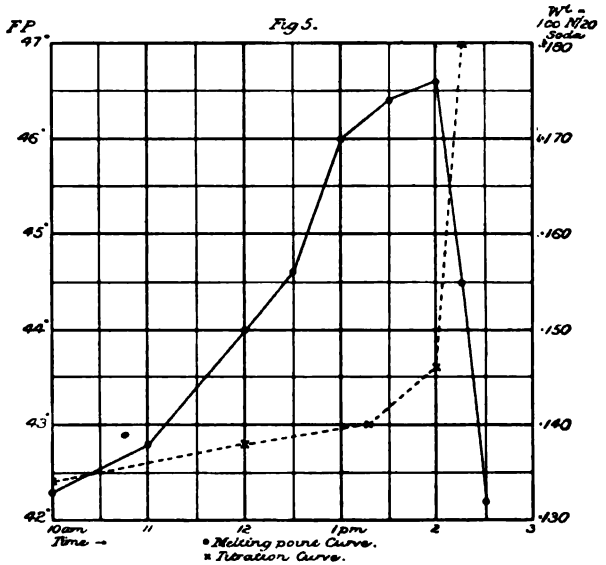
mixture in each case was found to contain the palmitic and stearic acids in the same proportion.



The next characteristic point in the curve is at Y (see fig. 1), where the freezing-point reaches its maximum value. The sudden fall that follows is due to the formation of new compounds of non-acid nature. This fact is well illustrated by a consideration of the curves in fig. 5, where the freezing-points and the weights of substance required to neutralise 1 c.c. of N/20 caustic soda are plotted on the same diagram. At the point where the freezing-point curve suddenly falls a rapid rise occurs in the other curve.

Experiments were then performed to investigate the nature of the new compound or compounds that had been produced. A sample of the last fraction was extracted with boiling alcohol several times, whereby all the acids were removed. There was left a dark-brown mass which melted under boiling alcohol. This proved to be a mixture which was separated

into two components by fractionally recrystallizing from benzine.



After seven recrystallizations the melting-point rose to 86°. The compound thus obtained was stearone (M.P. 88°), which is produced by the decomposition of two molecules of stearic acid :—

$$2\ C_{18}H_{36}O_2 = C_{35}H_{70}O + H_2O + CO_2$$

The stearone was identified by the preparation of the oxime, which melted constantly at 62° (Kipping gives the melting-point as 63°).

The more soluble product left in the mother-liquor after the stearine had been separated melted constantly at 72·3° after several recrystallizations from benzene. This is evidently the hydrocarbon $C_{35}H_{72}$ (M.P. 74°) formed from the stearone by reduction.

Soon the amount of stearone in the distillate becomes so great that the eutectic point is reached, and the melting-point begins to rise. This explains the minimum melting-point at Z. That this is the correct explanation was shown by the fact that, on adding a little stearone to the products obtained after this minimum had been reached, in each case the freezing-point was observed to rise. The addition of stearone to the product obtained before the minimum, on the other hand, caused a reduction in freezing-point.

The reason why the melting-point curve of the product from the second coil falls more slowly is because stearone tends to collect in the first coil, as it is less volatile than the stearic and oleic acids.

Towards the end of the operation the amount of oleic acid appears to be constant, but it is probable that some decomposition products, unsaturated in nature, are formed. This decomposition appears to be intimately connected with the unbearable smell which always becomes noticeable when the stearone is formed.

ART. LXI.—*The Association of the Fatty Acids and their Esters, and the Arrangement of Atoms in Space.*

By P. W. ROBERTSON.

[*Read before the Wellington Philosophical Society, 7th October, 1903.*]

IN a previous communication* were given the results of certain investigations on the association of the fatty acids in phenol solution. The work has been continued, and the normal fatty acids have been studied in greater detail. The results obtained for these compounds are given in Table I. The number of carbon atoms in the molecule is denoted by N, and A represents the rate of association of the acid.

TABLE I.

N.	Acid.	A.
2	Acetic	23
4	Butyric	14
6	Hexoic	12
8	Octoic	15
10	Decoic	28
12	Lauric	42
14	Myristic	—
16	Palmitic	80
18	Stearic	98

The rate of association of the acids with an even number of carbon atoms falls to a minimum at the sixth member, and then gradually rises with increase of molecular weight. The association of the earlier members has been shown to be due to the influence of the carboxylic group in the molecule. Some other explanation, however, must be given for the association of the higher fatty acids. An investigation of some closely related substances shows that the rapid rate of association is caused by a long chain of carbon atoms. The main grounds for this conclusion are as follows:—

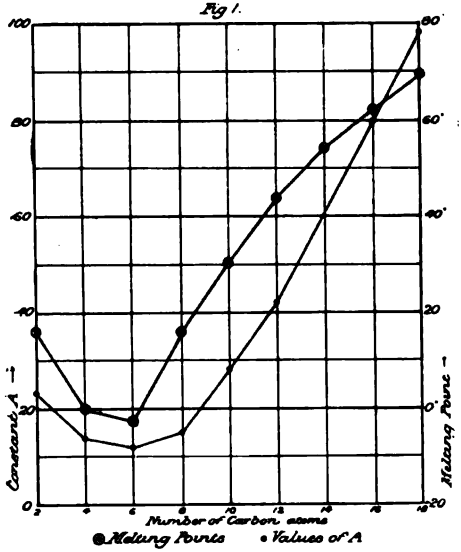
* Trans. N.Z. Inst., 1902, p. 452.

(1.) The hydrocarbons themselves associate rapidly in phenol solution.

(2.) The ethereal salts of the lower fatty acids have a negative value for A, and show little or no association. But ethyl laurate and ethyl palmitate associate rapidly, and the association is greater for the compound with the longer carbon chain.

(3.) The introduction of an ethylene linkage in stearic acid breaks the continuity of the hydrocarbon chain, and the rate of association is considerably reduced.

(4.) Amongst the lower fatty acids—butyric acid, for example—the introduction of a bromine atom in the α position to the carboxyl reduces A to about half its original value; higher up the series this is not the case, α brompalmitic acid associating almost as rapidly as palmitic acid itself.



Various other properties of the fatty acids show a minimum or maximum at the sixth member. The most characteristic example is furnished by the melting-points. These are graphically depicted with the values of A in fig. 1. The minimum is reached in both cases at the same acid, and the similarity between the two curves is readily noticeable. These results show clearly to what an extent the melting-point of a substance is dependent on its association. Further, they confirm the conclusion already arrived at*—namely, that "a maximum or minimum of a series is due to the molecular complexity of one or more members of that series."

* Trans. N.Z. Inst., 1902, p. 465.

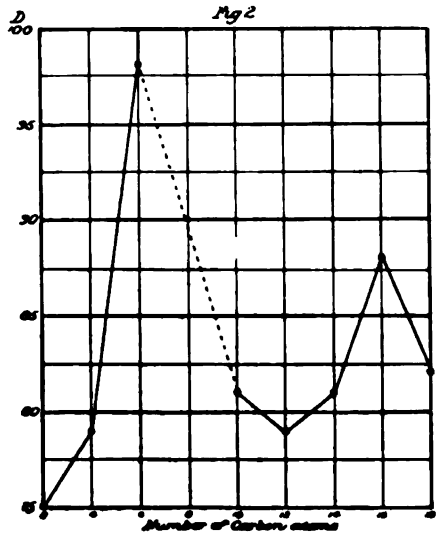
Some closely connected law seems to regulate the distribution of the fatty acids in nature. A rough analysis of the fatty acids obtained by the saponification of cocoa-butter showed that the compounds were present in the following proportions:—

Butyric acid (C_4)	... ...	2 per cent.
Hexoic acid (C_6)	... ...	0 "
Octoic acid (C_8)	... ...	1 "
Decoic acid (C_{10})	... ...	4 "
Lauric acid (C_{12})	... ...	50 "

Here again it is the sixth member which occurs to the smallest extent.

Though smell is a property concerning which little is known, yet it does not seem entirely devoid of interest to mention that of all the even fatty acids hexoic acid has the most repugnant odour. Thus it seems as if, in the case of the cocoa-tree, the most offensive acid is prepared in the least quantity by the plant.

A study of the cyoscopic behaviour of the normal fatty esters in phenol solution gives somewhat similar results, in that it is again at the sixth member that a sudden change is exhibited. In the case of these compounds, however, there is also a change of the opposite nature at the compound with twelve atoms. This appears to be the first instance known of the regular occurrence of both a maximum and minimum in the same series of compounds.



The data for the even members of the normal fatty esters are given in Table II. D represents the initial molecular depression for a fall of 0·5°.

TABLE II.

N.	Ester.	D.
2	Ethyl acetate	75
4	Ethyl butyrate	79
6	Ethyl hexoate	98
8	Ethyl octoate	—
10	Ethyl decoate	81
12	Ethyl laurate	79
14	Ethyl myristate	81
16	Ethyl palmitate	88
18	Ethyl stearate	82

The values of D are plotted against N (the number of atoms in the acid portion of the molecule) in fig. 2. The resulting curve shows a minimum and two distinct maxima.

According to Baeyer's tension theory a chain of six carbon atoms bends round to form a ring in space. But, as shown above, there is a considerable tendency for the formation of maxima or minima in the case of compounds with a chain of six and twelve carbon atoms. Hence it appears that association, which has been shown to cause the appearance of a maximum or minimum, is largely influenced by the arrangement of the atoms in space. Further, the regular rise and fall in the properties of the esters of the fatty acids can be explained on the assumption of Baeyer's hypothesis of the configuration of a chain of carbon atoms in space.

ART. LXII.—*A Flash of Lightning.*

By Archdeacon WALSH.

[*Read before the Auckland Institute, 12th September, 1904.*]

ABOUT last February a thunderstorm passed over the district of Taiamai, a tract of volcanic country lying about half-way between the Bay of Islands and Hokianga. The discharges were not very frequent, but were unusually heavy. One of them fell in a fairly level paddock close to the coach-road from Ohaeawai to Kaikohe, about half a mile from the former place. A wagon drawn by a team of horses was passing at the time, when the horses, terrified by the blinding flash, bolted, and the wagon was upset. It was raining in torrents, and a couple of Maoris, who were standing under the verandah of a cottage some three or four hundred yards off, stated that the

water appeared to bubble on the ground, and that steam kept rising for half an hour from the spot that had been struck.

The phenomenon was plainly visible from the Township of Ohaeawai, and an animated discussion arose among some of the inhabitants as to its origin and results. By a too hasty generalisation the "thunderbolt"—as they agreed to call the electric discharge—was confused with the fall of a meteorite, and an individual who claimed to have some knowledge of the subject informed them that if the celestial visitor could be secured it would prove of considerable commercial value. He estimated that it would be worth at least £20, whether regarded merely as a curio or as a mass of marketable metal.

Their scientific curiosity whetted by the hope of a financial return, a party of young men set out on a search expedition. They had no difficulty in finding the spot, and on arrival discovered a circular hole in the ground about 4 in. in diameter, surrounded by a number of similar perforations on a smaller scale, the whole set occupying a space of perhaps 2 or 3 yards square. It was evident that the discharge had split off into several branches on approaching the ground. It was not explained how twenty pounds' worth of meteoric iron could have forced its way through so narrow a passage; but, nevertheless, they started to dig. Failing, however, to bottom the hole at the depth of 6 ft., they sounded with a piece of fencing-wire, and as this went down for another 14 ft. the sinking was regretfully abandoned.

Taking an early opportunity to visit the scene of operations, I found that the excavation had been filled up, and as the ground had been so trampled by the explorers all trace of the smaller holes had disappeared. I should like to have been able to examine the hole. There is no doubt that it was caused by the lateral expansion of the steam generated in the wet ground by the intense heat of the electric discharge. It is well known that on the passage of a lightning-spark through a bed of sand a tube of vitreous matter called a "fulgurite" is sometimes formed by the fusion of the particles of silica. Possibly some similar formation would take place in a stratum of clay; but in the volcanic ground of Taiamai, already subject to the extreme action of fire, it is unlikely that further metamorphosis could take place, and any change in the structure would be only due to compression. It would have been interesting, however, to see whether the compression had been sufficient to form a definite tube.

RECORDS OF MILNE SEISMOGRAPHS.

Records of the Milne Seismographs Nos. 16 and 20, taken at Christchurch and Wellington, by Mr. Skey and Mr. Hogben.

Communicated by Mr. G. Hogben, Secretary for Education.

Plates L.–LIV.

Records of Milne Seismograph No. 16, at Christchurch, New Zealand.

Latitude, 43° 31′ 50″ S.; longitude, 172° 37′ 18″ E. Time employed: Greenwich mean civil time.

P.T., preliminary tremors less than 2 mm. complete range; A.T., after-tremors less than 2 mm. complete amplitude; B., E., beginning and end of vibrations not less than 2 mm.; Amp., in millimetres; 1 mm. boom motion = 0″.43. B. and E. signify beginning and end of amplitudes exceeding 1 mm., the range being 2 mm.

H. F. Skey, Observer.

Date.	P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	B.P.	Remarks.
1908.					Mm.			Secs.	
Jan. 4	5.12·1	5.15·2	5.18·8	..	0·9	..	..	..	
			5 28·8	..	1·65				
			5.23·7	..	1·6				
			5.31·2	..	1·3				
			5.35·6	..	1·25	5.36·7	7.20·6	..	
„ 9	1.46·9	2.01·9	2.02·9	..	0·75	2.04·9	2.28·3	..	
„ 14	2.06·4	2.36·4	2.44·8	..	4·75	3.12·5	5.17·3	..	Origin N.E. of Marquesas Islands (?)
„ 17	16.53·0	16.58·1	17.02·1	..	2·5	17.07·7	19.43·0	..	
„ 26	2.20·8	..	2.21·0	..	0·3	..	2.28·0	..	
Feb. 10	3.11·4	3.24·6	3.26·5	..	0·75	3.28·5	..	..	

Feb.	21	..	..	8.09·3	..	0·05	..	..	..	Tremors lasting 2 or 3 min. each.
"	21	..	..	8.10·7	..	0·05	..	..	..	
"	21	..	..	8.18·1	..	0·05	..	..	..	"
"	21	..	..	8.26·0	..	0·05	..	..	..	"
"	21	..	..	8.29·3	..	0·1	..	..	..	"
"	21	..	..	8.33·4	..	0·05	..	..	..	"
"	21	..	..	8.36·3	..	0·05	..	..	..	"
"	26	5.57·9	..	6.04·0	..	0·15	..	6.24·2	..	"
"	27	0.54·6	..	1.26·7	..	2·4	..			"
				1.31·4	..	3·75	..	5.05·0	..	
						3·0	1.37·4			
Mar.	26	8.54·7	..	9.06·2	..	1·0	..	9 37·0	..	
"	30	3.38·6	3.53·8	4.01·1	..	0·75	4.10·0	5.43·7	..	
April	1	2.48·1	..	..	.	..	2.54·7	2.54·7	..	Local; felt at Pipiriki. Began 2 h. 51 m. 50 sec.; ended 2 h. 52 m. 10 sec. (by chronometer).
"	1	3.00·7	..	..	..	..	..	..	..	Sudden and short.
"	29	4.10·8	4.17·6	4.19·6	4.28·8	4·2	4.31·9	6.17·1	..	
"	29	..	..	13.17·6	..	0·6	..	..	..	P.T. and A.T. obscured by night tremors.
May	8	4.32·5	..	4.42·0	..	1·0	..	5.04·6	..	
"	13	6.42·4	6.49·0	7.01·7	..	6·5	7.27·9	9.18·4	..	
"	19	8.14·0	..	..	..	0·5	..	8.30·5	..	
"	27	23.40·6	..	..	..	0·4	..	23·42·7	..	
"	29	23.01·5	..	..	..	0·2	..	23.04·6	..	
June	8	5.34·5	5.45·8	5.49·5	..	1·0	..	7.08·9	..	
"	9	11.16·6	11.18·1	11.18·7	..	0·7	11.23·2	12.04·9	..	
"	10	16.49·7	16.59·2	17.02·8	..	1·5	17.11·4	..	..	Minute thickenings for some hours.
"	15	22.18·1	22.21·3	22.22·9	..	1·0	..	22.53·1 +	..	
"	21	7.43·9	..	..	..	..	..	8.17·3	..	Minute irregularities for considerable time before and after.
July	2	21.21·6	21.28·9	21.30·5	..	1·4	21.34·9	22.13·3	..	
"	9	4.52·2	..	5.19·3	..	..	..	5.26·7	..	Thickening merely.
"	10	4.11·4	..	4.15·0	..	..	..	4.36·6	..	"
"	12	4.28·3	4.37·5	4.46·7	..	2·5	4.52·3	5.19·0	..	Origin New Britain (?).

Records of Milne Seismograph No. 16—*continued.*

Date.	P.T. (from)	B.	Maxima From	Maxima To	Amp.	E.	A.T. (till)	B.P.	Remarks.
1908.					Mm.			Secs.	
July 19	13.10·5	..	13.15·0	..	..	..	13.23·1	..	Thickening merely.
„ 28	4.35·0	..	..	..	..	..	4.47·0	..	
Aug. 1	10.00+	..	..	..	..	..	20.00+	..	Tremor (shocks felt in Hawke's Bay Province).
„ 7	7.54·2	..	7.55·2	..	0·3	..	8.01·4	..	
„ 19	9.43·6	..	9.55·0	..	0·5	..	10.15·7	..	
„ 24	7.29·7	..	7.36·4	..	..	..	7.53·8	..	Thickening merely.
Sept. 3	6.05·3	6.25·3	6.26·5	..	1·2	6.30·4	7.24·3	..	
„ 5	5.45·2	..	5.49·4	..	..	..	5.57·6	..	Thickening merely.
„ 7	7.17·0	7.24·2	7.28·9	..	14·0	7.47·2	8.12·0	..	
„ 8	5.23·4	..	5.36·9	..	0·6	..	6.31·7	..	
„ 23	0.17·0	..	0.21·7	..	0·8	..	0.32·0	..	
„ 23	7.19·1	..	7.23·2	7.31·5	0·5	..	7.50·0	..	
„ 26	6.15·0	6.17·2	6.17·8	..	1·3	6.18·0	6.39·4	..	
Oct. 4	5.02·4	5.04·1	5.05·7	..	1·0	5.12·0	5.29·5	..	
„ 13	22.04·1	..	22.10·4	..	0·5	..	22.14·5	..	
„ 14	3.32·2	..	3.52·8	..	0·8	..	4.09·3	..	
„ 17	..	..	..	..	..	..	2.09·0	..	In progress while attending to instrument.
„ 20	14.48·9	14.52·0	14.53·0	..	2·2	14.58·7	15.38·6	..	
„ 20	Indef.	14.29·9	14.36·5	..	11·5	..	..	..	P.T. and A.T. obscured by night tremors.
			Max. between						
„ 30	3.30·1	4.05·1	4.10·0 and	4.20·0	6·0+	4.30·2	6.29·9	..	Attending to instrument during maxima.
„ 30	12.00+	15.07·0	15.07·3	..	1·3	15.12·4	21.00+	..	
Nov. 1	18.02·5	..	18.07·7	..	1·0	..	18.36·2	..	
„ 2	3.00·0	..	3.01·1	..	0·6	..	3.08·3	..	

Nov.	10	17.23·0	17.23·6	17.29·2	..	3·5	17.45·5	18.20·5	..	
"	10	20.58·3	21.02·2	21.04·3	..	1·8	21.07·0	21.23·4	..	
Dec.	23	..	1.12·3	1.19·3	1.20·0	3·6	1.25·2	2.13·3	..	
"	23	23.45·0	..	23.51·3	23.55·4	0·6	..	24.08·0	..	
"	24	21.26·0	..	21.32·2	..	0·9	..	21.40·4	..	
"	28	3.07·0	..	3.35·7	..	1·0	..	4.12·1	..	
"	31	Indef.	14.10·7	14.13·8	..	4·5	14.24·1	Indef.	..	Obscured by night tremors.
1904.										
Jan.	2	0.05·8	..	0.10·0	..	1·0	..	0.41·8	..	
"	7	Indef.	2.52·7	2.54·8	..	7·5	3.19·8	Indef.	..	P.T. and A.T. obscured by night tremors.
"	10	3.01·8	3.12·4	3.13·0	..	2·9	3.19·0	4.13·0	..	
"	20	Indef.	15.49·8	15·52·5	..	4·5	16.08·0	Indef.	..	P.T. and A.T. obscured by night tremors.
"	25	Indef.	..	..	..		3.53·0	4.06·7	..	In progress while attending instrument.
"	29	0.12·3	..	0.41·0	..	0·9	..	1.09·2	..	
Feb.	4	10·31·4	..	10.35·8	..	1·0	..	11.03·4	..	
"	8	5.47·5	..	5.51·1	5.54·2	0·8	..	6.05·1	..	
"	18	5.59·9	6.03·1	6.03·9	..	2·0	6.05·9	6.16·2	..	
"	20	10.15·0	..	10.19·0	..	0·8	..	10.30·0	..	
"	22	Indef.	1.29·7	1.31·0	..	1·8	1.32·7	2.06·3 +	..	
"	28	5.42·8	..	6.00·5	..	0·5	..	6.45·3	..	
Mar.	1	Indef.	3.22·2	3.23·7	..	2·5	3·29·9	Indef.	..	P.T. and A.T. obscured by night tremors.
"	1	Indef.	4.26·0	4.30·1	..	4·0	4.39·9	Indef.	..	" "
"	2	9.09·9	9.13·0	9.15·0	..	2·5	9.31·5	9.49 +	..	
"	8	8.49·1	..	8.50·7	..	0·5	..	8.56·4	..	
"	3	11.02·8	11.11·7	11.20·4	..	1·8	11.30·4	11.52·9	..	
"	16	7.50·1	..	7.55·4	..	0·5	..	8.16·5	..	
"	26	Indef.	15.08·9	15.11·0	..	4·5	15.15·6	Indef.	..	P.T. and A.T. obscured by night tremors.
"	29	10.07·8	10.20·3	10.21·8	..	1·0	10.23·9	Indef.	..	
April	4	10.41·6	..	12.26·4	12.38·5	0·5	..	13.13·8	..	Salonika (?).
"	6	0.12·3	..	..	..	..	..	0.20·5	..	Thickening merely.
"	11	Indef.	14.11·3	14.12·9	14.15·9	4·3	14.23·6	Indef.	..	P.T. and A.T. obscured by night tremors.
May	1	6.39·5	6.42·5	6.51·8	..	3·8	6.55·9	8.07·1	..	
"	1	15.35·7	15.55·5	16.06·7	16.11·4	5·5	16.17·5	Indef.	..	A.T. obscured by night tremors.
"	1	23.39·6	..	24.00·0	..	1·3	..	24.30·8	..	

RECORDS OF MILNE SEISMOGRAPH No. 16—*continued.*

Date.	P.T. (from)	B.	Maxima		Amp.	E.	A.T. (till)	B.P.	Remarks.
			From	To					
1904.					Mm.			Secs.	
May 21	15.12·4	..	15.16·5	..	0·4	..	15.44·2	..	
„ 28	23.39·6	..	23.55 0	..	1·3	..	0.57·0	..	
June 10	18.59·2	..	19.05·1	..	..	..	19.37·9	..	Thickening merely.
„ 13	15.33·6	..	15.38·8	..	..	..	15.44·0	..	Very slight.
„ 13	17.22·3	..	17.25·9	..	..	..	17.28·4	..	„
„ 17	Indef.	..	6.39·5	..	..	..	Indef.	..	Elongated swelling. P.T. and A.T. obscured by night tremors.
„ 17	Indef.	..	13.29·2	..	0·5	..	Indef.	..	P.T. and A.T. obscured by night tremors.
„ 17	19.18·0	..	19.31·3	..	0·5	..	19.38·4	..	
„ 18	6 25·9	6.32·3	6.38·4	..	2·7	6.42·0	7.18·5	..	
„ 26	19.58·2	..	20.20·7	..	0·9	..	21.11·5	..	
„ 26	21.25·9	..	22.22·8	..	1·3	..	24.31·0	..	
„ 27	0.32·5	..	1.31·0	1.36·1	0·9	..	3.07·4	..	In progress while attending instrument.
July 12	1.54·5	..	2.01·7	..	0·3	..	2.13·0	..	
„ 22	0.49·3	1.0·26	1.04·1 1.07·2	1.10·6	4·0	1.14·4	2.21·0	..	
„ 22	15.23·5	..	15.35·8	..	0·5	..	16.12·2	..	
„ 27	Indef.	15.58·5	16.00·1	..	2·2	16.05·1	Indef.	..	P.T. and A.T. obscured by night tremors.
Aug. 8	..	..	..	..	..	23.03·4	24.43·7	..	Severe shocks at Wellington. Light out at commencement of quake.
„ 14	2.56·1	2.59·7	3.01·3	..	5·7	3.10·0	3.44·8	..	
„ 16	22.20·3	..	..	..	..	..	22.24·6	..	Very slight and sudden.
„ 18	Indef.	5.18·4	5.21·8	..	3·5	5.27·0	5.52·8	..	P.T. obscured by night tremors.
„ 19	2.31·7	..	2.34·8	..	..	..	2.40·1	..	P. slight swelling.
„ 22	1.37·4	..	Max. at	begin'ng	0·5	..	1.43·6	..	P. slight and sudden.

Aug.	24	Indef.	21.32·6	21.40·3	..	2·05	22.05·3	Indef.	..	P.T. and A.T. obscured by night tremors.
Sept.	6	2.05·2	..	2.08·3	..	0·55	..	2.13·5	..	
"	9	1.23·9	..	1.33·2	..	1·0	..	2.08·3	..	
"	9	Indef.	20.42·1	20.48·8	..	2·4	20.55·4	Indef.	..	P.T. and A.T. obscured by night tremors.
"	13	6.35·8	..	6.42·5	..	0·5	..	7.10·4	..	
"	13	Indef.	17.18·2	17.25·4	..	5·2	17.37·9	Indef.	..	P.T. and A.T. obscured by night tremors.
"	17	Indef.	20.11·3	20.11·8	..	1·2	20.13·9	Indef.	..	" "
"	17	Indef.	..	23.47·0	..	0·4	..	..	..	" "
"	19	4.59·1	5.04·0	5.12·7	6.40·9	5·1	5.38·3	7.19·9	..	Very slight waves until second maximum is reached.
"	20	3.16·3	..	3.18·8	3.24·0	0·4	..	3.48·6	..	
"	24	Indef.	15.11·6	15.14·7	15.15·8	17+	15.45·0	Indef.	..	P.T. and A.T. obscured by night tremors.
"	27	2.23·4	..	2.26·0	..	0·25	..	2.38·4	..	
Oct.	3	3.54·4	..	4.31·0	..	0·65	..	6.04·9	..	
"	4	0.06·8	0.09·9	0.10·4	..	2·05	0.10·9	0.49·9	..	
"	10	12.56·9	..	13.00·5	..	0·3	..	13.05·2	..	
"	10	14.00·3	..	14.05·5	..	1·4	..	14.25·6	..	
"	11	9.57·3	..	10.01·2	..	0·8	..	10.08·2	..	Night tremors (?).
"	16	5.41·1	..	5.46·0	..	0·4	..	6.31·8	..	
"	19	3.14·2	..	3.17·8	..	0·45	..	3.42·6	..	
"	28	5.01·9	..	..	..	..	..	5.13·2	..	Thickening merely.
"	28	Indef.	14.28·2	14.29·3	..	1·6	14.30·0	..	..	P.T. and A.T. obscured by night tremors.
"	31	1.31·1	..	1.33·4	..	0·25	..	1.42·0	..	
Nov.	3	3.49·0	..	4.00·9	..	0·8	..	4.21·6	..	
"	8	7.01·0	..	7.08·2	..	0·25	..	7.18·6	..	
"	21	3.18·7	3.21·0	3.25·6	..	6·0	3.50·4	5.08·0	..	
"	22	1.21·2	..	1.38·7	..	0·55	..	2.59·2	..	
Dec.	3	1.57·6	3.20·8	3.23·7	..	2·25	3.28·1	4.25·0	..	
"	9	..	..	6.30·2	..	1·4	..	..	..	Sudden displacement.
"	9	..	..	21.08·2	..	0·55	..	..	..	"
"	19	Indef.	..	17.55·7 17.57·8	..	14·0 14·5	..	Indef.	..	Obscured by night tremors.
"	20	5.59·8	6.35·3	6.39·1	..	3·4	6.58·8	8.39·1	..	

Records of Milne Seismograph No. 20, at Wellington, from January, 1903, to December, 1903 (inclusive).

Latitude, 41° 17′ S.; longitude, 174° 47′ E. Greenwich mean civil time. Midnight, 0 h. or 24 h.; hours, 1 to 24. Time in hours, minutes, and tenths of minutes.

P.T., preliminary tremors. A.T., after-tremors. B., E., beginning and end of vibrations generally not less than 2 mm. Amp., full amplitude in millimetres.

The instrument is placed in a special room below a house standing about 30 ft. from the edge of a rocky cliff about 50 ft. high, situated about 250 yards from the shore-line of Wellington Harbour.

George Hogben, Observer.

Date.	P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	B.P.	Remarks.
1903.					Mm.			Secs.	
Jan. 14	2.04·8	2.31·2	2.38·8	..	16·5	4.43·6	..	..	
„ 17	16.29·0	16.32·3	16.59·8	..	4·0	17.44·4	..	..	
Feb. 28	10.14·9	10.30·3	10.34·9	..	1·0	10.47·2	..	..	
April 10	..	15.16·6	15.20·8	..	1·5	15.27·8	..	..	
„ 29	3.08·4 3.45·0 3.57·9 4.15·2	4.17·8	4.22·2	4.48·3	11·2	6.28·8	..	..	
May 13	6.34·1	6.42·3 or 6.48·7	6.58·0	..	7·0	8.06·3	10.40·6	..	
„ 31	6.32·5	6.35·9	6.39·1	..	3·5	6.52·1	..	..	
June 8	5.31·9	5.46·1	5.49·1	..	1·5	6.39·1	..	..	
„ 10	16.48·5	16.56·4	17.00·5	..	1·5	17.19·8	..	..	
1904.									
Mar. 26	15.08·1	15.08·5	15.08·9	..	2·0	15.10·6	15.18·7	15·5	Felt at Invercargill and Dunedin (R. F. W.).
April 23	..	11.57·5	11.58·5	..	1·0	11.59·9	..	16·7	

May	1	6.24·4	6.40·0	6.41·8	6.48·1	7·5	6.54·2	9.20·0	16·4	P.T. and A.T. obscured by tremors.
"	1	15.46·2	16.02·1	16.02·5	16.15·9	4·0	16.22·6	16.59·3	16·4	
"	1	(23.36·0) or (23.39·6)	23.57·3	23.58·4	..	1·9	24.03·8	24.34·5	16·4	
"	19	13.23·0	13.49·0	13.51·7	..	1·6	13.56·4	(?)	16·3	" "
June	18	6.20·8	6.30·5	6.39·1	..	1·2	6.44·7	7.51·8	..	
"	25	15.14·8	15.45·0	16.05·9	..	1·0	16.09·8	17.42·5	16·1	
"	25	21.29·8	21.59·7	22.06·5	22.19·8	2·0	22.27·5	24.12·0	16·1	
"	26	20.00·1	20.17·8	20.20·8	20.22·4	0·6	20.22·9	21.57·0	16·1	
"	27	0.32·5	1.09·4	1.30·5	1.35·5	1·6	1.43·0	3.11·5	16·1	
July	23	0·55·4	1.02·4	1.09·8	1.14·8	5·4	1.17·0	(?)	16·0	A.T. obscured by tremors.
Aug.	14	2.54·1	2.56·0	2.57·0	2.58·0	3·8	3.07·0	(?)	..	EQ. at Waipawa, &c. East Coast origin.
"	18	5.01·8	5.12·8	5.15·9	..	3·6	5.18·1	5.39·0	..	
"	24	21.18·0	21.42·5	21.43·8	..	1·5	21.51·5	(?)	16·0	A.T. obscured by EQ. East Coast origin.
"	27	(21.48·0) or (21.58·1)	22.01·2	22.14·5	22.31·9	1·6	22.37·3	23.47·3	16·0	Time (?).
Sept.	13	17.16·1	17.17·0	17.23·4	17.25·1	5·0	17.27·3	18.17·7	17·2	
"	15	16.31·2	16.32·4	16.35·9	16.40·9	0·6	16.41·9	16.49·8	17·2	
"	25	14.36·5	14.39·2	14.41·3	14.54·1	13·5	14.57·2	15.45·8	17·2	
Oct.	3	4.06·5	4.18·5	4.23·7	..	1·0	4.26·2	4.51·2	17·0	
"	4	0.10·1	0.11·6	0.12·6	..	1·5	0.15·6	0.20·7	17·0	
"	7	7.19·7	8.01·1	8.02·7	(?)	25·5	(?)	(?)	16·9	Case opened while EQ. in progress.
"	9	..	13.59·1	14.00·4	..	1·2	14.02·5	14.56·0	16·9	
"	11	..	9.55·1	9.56·3	..	0·6	9.59·2	..	16·8	
"	16	5.30·3	5.41·6	5.45·9	..	0·5	5.52·0	About 6.15·0	16·8	
"	19	..	3.18·0	3.24·0	..	0·5	3.25·9	About 3.35·0	16·8	
"	28	14.15·6	14.26·5	14.31·8	..	4·1	14.38·9	15.07·0	17·0	
Nov.	21	3 01·5	3.15·3	3.17·4	3.32·0	3·1	3.34·9	4.31·3	17·2	
Dec.	2	3.08·9	3.10·9	3.12·3	3.16·4	1·5	3.19·5	3.53·2	17·2	
"	11	9.16·1	9.19·2	9.24·5	9.32·6	1·8	9.35·5	(?)	17·1	A.T. obscured by tremors

NEW ZEALAND INSTITUTE

NEW ZEALAND INSTITUTE.

THIRTY-SIXTH ANNUAL REPORT.

In November, 1903, the New Zealand Institute was reconstituted by the passing of "The New Zealand Institute Act, 1903," and the following is the report of the Institute for the past twelve months. The Act of 1903 has completely changed the constitution of the Institute, for whereas formerly the various incorporated societies had the power merely of nominating members, of which three were elected by the Board of Governors, now the various societies elect twelve out of a total of eighteen. This practically places the management of the Institute in the hands of the various incorporated societies. Another change is to make every member of the incorporated societies a member of the Institute. This will bring every member in closer touch with the Institute.

Only one meeting of the old Board was held since the last annual report was printed—viz., the 23rd November, 1903.

The first meeting of the new Board was held on the 21st and 22nd January, 1904, in the Museum, Wellington, and was attended by thirteen members.

Captain Hutton, F.R.S., was elected President; Mr. J. W. Joynt, M.A., Treasurer; Mr. T. H. Gill, M.A., LL.B., Secretary; Mr. A. Hamilton, Editor of the Transactions and Librarian.

The following vote of thanks was placed on record for the eminent services rendered to the Institute and the cause of science by Sir James Hector, F.R.S.: "That the Board of the New Zealand Institute expresses its regret at the retirement of Sir James Hector from the active management of its affairs, and begs to place on record its high appreciation of the eminent services rendered by him to the Institute and to the cause of science."

The members now on the roll are—Honorary members, 28; Auckland Institute, 147; Hawke's Bay Philosophical Institute, 53; Wellington Philosophical Society, 152; Philosophical Institute of Canterbury, 85; Otago Institute, 111; Nelson Institute, 19; Westland Institute, 63: making a total of 646.

The volumes of Transactions now on hand are—Vol I. (second edition), 325; Vol. V., 41; Vol. VI., 32; Vol. VII., 154; Vol. IX., 226; Vol. X., 147; Vol. XI., 402; Vol. XII., 315; Vol. XIII., 152; Vol. XIV., 117; Vol. XV., 290;

Vol. XVI., 280; Vol. XVII., 541; Vol. XVIII., 319; Vol. XIX., 565; Vol. XX., 463; Vol. XXI., 466; Vol. XXII., 572; Vol. XXIII., 581; Vol. XXIV., 682; Vol. XXV., 638; Vol. XXVI.. 626; Vol. XXVII., 618; Vol. XXVIII., 702; Vol. XXIX., 605; Vol. XXX., 699; Vol. XXXI., 710; Vol. XXXII., 533; Vol. XXXIII., 626; Vol. XXXIV., 579; Vol. XXXV., 541. These are now stored in the Parliamentary Buildings.

The volume just published (XXXVI.) contains fifty articles, also addresses and abstracts which appear in the Proceedings. It consists of 568 pages and forty-four plates. The following is a comparison of the contents of Vol. XXXVI. with those of Vol. XXXV.

	1903. Pages.	1902. Pages.
Miscellaneous	129	305
Zoology	90	77
Botany	169	64
Geology	108	16
Chemistry and physics	11	77
Proceedings	23	29
Appendix	38	55
	568	623

The whole of the work was done at the Government Printing Office.

By an Order in Council of the 29th August, 1904, copies of which were sent to all the incorporated societies of the New Zealand Institute, the property of the New Zealand Institute, previously vested in the Board of Governors under the Act of 1867, is vested in the Board of Governors under the New Zealand Institute Act of 1903. The schedule of property so transferred consists, *inter alia*, of £2,247 9s. 5d., being residue of the bequest of the late Charles Rooking Carter for the purpose of establishing an astronomical observatory.

Acting under instructions of the last meeting of the Board of Governors, the Colonial Secretary was communicated with on the 30th January, 1904, asking for railway passes to members of the Board when attending meetings of the New Zealand Institute, and a reply was received on the 8th March that the Colonial Secretary was not prepared to grant free railway passes to members of the Board of Governors, nor to defray the cost of their steamer-fares when attending meetings of the Institute. The matter will come up for consideration, as Mr. Hill, of Napier, has given notice of motion dealing with this matter.

A number of applications for interchange of Proceedings

have been received from other scientific societies. It might be advisable to set up a committee similar to the Library Committee set up at the last meeting, by whom these applications could be considered and dealt with. This would be better than leaving them until the next annual meeting.

The balance-sheet shows receipts to the amount of £537 6s. 8d. (including Government grant of £500). The sale of "Maori Art" accounts for the balance. The disbursements total £537 7s. 11d., the largest item of which is printing the Institute's Transactions, £350 16s. 3d.

STATEMENT OF THE RECEIPTS AND PAYMENTS OF THE NEW ZEALAND INSTITUTE FOR THE YEAR ENDED 31ST DECEMBER, 1904

Receipts.

	£	s.	d.
Balance from 1903	418	3	0
Sale of "Maori Art"—			
Per S. and W. Mackay	7	5	2
„ Champtaloup and Cooper	6	13	6
„ Quaritch (London)	19	4	0
Sold direct	4	4	0
Government grant	500	0	0
	£955	9	8

Expenditure.

	£	s.	d.
Salaries—			
Editor	50	0	0
Secretary	25	0	0
Acting-Secretary	11	17	6
Librarian	20	0	0
Printing Transactions, Vol. XXXVI.	350	16	3
Wages and work in library	49	0	0
Compiler of the slips for the International Science Catalogue of Scientific Literature*	10	0	0
Cartage	4	14	6
Steel die for stamp	2	0	0
Repairs	1	15	3
Stationery, typewriting, and petty charges ...	12	4	5
Balance in bank	418	1	9
	£955	9	8

Audited and found correct.

WM. BEAUCHAMP PLATTS.

Wellington, 16th January, 1905.

* See report of International Council, appended.

INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

The New Zealand Institute having been appointed regional bureau in this country for the International Catalogue of Scientific Literature, in accordance with the wish of the International Council, publishes the following balance-sheets:—

1. Balance-sheet, 29th February, 1904.

Liabilities.

	£	s.	d.
Loan from Royal Society—			
Amount free of interest	300	0	0
Amount subject to interest at 4 per cent. per annum	3,500	0	0
Subscriptions from countries received in advance	649	6	0
Accounts in respect of the first annual issue unpaid—			
Printing and binding	683	18	10
Publishers' commission	30	0	0
Experts' fees	109	0	0
	£5,272	4	10

Assets.

	£	s.	d.	£	s.	d.
Furniture	137	0	6			
Typewriting machinery ...	69	11	7			
Office fixtures	19	9	0			
Catalogue apparatus ...	79	7	6			
Reference books	45	4	7			
	350	13	2			
Less one-tenth thereof transferred to Income and Expenditure Account	35	1	4			
				315	11	10
Preliminary expenses incurred before 31st December, 1901—						
Printing	763	10	6			
Director	500	0	0			
Honorarium to Dr. Morley as secretary of Provisional International Committee	250	0	0			
Carried forward ...	1,513	10	6	315	11	10

Assets—continued.

	£	s.	d.	£	s.	d.
Brought forward ...	1,513	10	6	315	11	10
Preliminary expenses, &c.—*ctd.*						
Rent of office	213	0	0			
Legal charges	77	11	2			
Salaries	335	4	2			
Travelling-expenses ...	9	3	1			
Stationery	45	11	5			
Office expenses	26	3	10			
Postage and telegrams ...	61	1	8			
	2,281	5	10			
Less one-fifth thereof transferred to Income and Expenditure Account	456	5	2			
				1,825	0	8
Amount due from countries, &c., for volumes sold	...			2,648	0	0
Suspense Account—						
Payments on account of second annual issue ...	1,518	13	1			
Less received for volumes sold	1,342	7	3			
				176	5	10
Balance at bank—						
Robarts, Lubbock, and Co.	192	2	1			
Union of London and Smiths Bank	81	9	8			
Balance in hand	0	5	0			
				273	16	9
Excess of expenditure over income on the first annual issue	...			33	9	9
				£5,272	4	10

I have examined the above balance-sheet and accompanying Income and Expenditure Account with the books and vouchers, and have found them correct. I have also verified the balance at the bankers'. Administrative expenditure has been apportioned by the directors between preliminary expenses and expenses of the first and second annual issues.

W. B. KEEN, Chartered Accountant.

3, Church Court, Old Jewry, E.C.,
27th April, 1904.

2. INCOME AND EXPENDITURE ACCOUNT OF THE FIRST ANNUAL ISSUE.

Expenditure.	£	s.	d.
Printing and binding	3,444	11	0
Publishers' commission	330	4	8
Experts' fees	614	3	4
Expenditure from 1st January, 1902, to 30th June, 1903—			
Director	750	0	0
Salaries	817	5	2
Rent of office...	345	0	0
Stationery and catalogue cards	53	17	9
Office expenses	33	3	8
Postages and telegrams	45	12	9
Insurance			
Interest on loan	183	11	
One-tenth of cost of furniture, &c., written off, as per balance-sheet	35	1	
One-fifth of preliminary expenses written off, as per balance-sheet	456	5	2
	£7,117	0	0

Income.	£	s.	d.
Sales of subscription copies	6,913	18	6
Sales of trade copies	169	11	9
Excess of expenditure over income carried to balance-sheet	33	9	9
	£7,117	0	0

[No estimate has been made of the income expected from the number of copies not yet sold, which at the 29th February, 1904, were about 12,700.]

PROCEEDINGS

WELLINGTON PHILOSOPHICAL SOCIETY.

First Meeting: *11th May, 1904.*

Professor Easterfield, President, in the chair.

New Member.—Mr. A. T. Clarke.

The President announced that the Council was endeavouring to arrange for the delivery of a series of popular lectures under the auspices of the Society. He had pleasure in stating that Mr. Augustus Hamilton had consented to give the first lecture, the subject to be "Maori Art."

Professor Easterfield then delivered his presidential address on "Recent Advances in Technical Chemistry."

At the conclusion of the address a cordial vote of thanks was passed to Professor Easterfield.

Second Meeting: *1st June, 1904.*

Professor Easterfield, President, in the chair.

New Member.—Mrs. Kate Mason.

The President announced that Mr. Thomas King had been elected Secretary and Treasurer of the Society, vice Mr. A. H. Gore, resigned; also that Mr. Cuthbert Freyberg had been appointed Librarian.

On the motion of the President, seconded by Professor Kirk, it was resolved that in future the meetings of the Society should be held at 8 p.m. instead of at 7.45 p.m.

Papers.—The following papers were read:—

1. "Notes on the Entomology of Mount Holdsworth, Tararua Range," by G. V. Hudson, F.E.S. (*Transactions*, p. 334.)

Professor Kirk spoke of the importance of the question raised by the author as to the distribution of species in the North and South Islands of the colony. He considered that on this expedition Mr. Hudson had done valuable entomological work.

Mr. C. E. Adams bore out what Mr. Hudson had said as to the meteorological conditions prevailing on Mount Holdsworth and on the neighbouring portions of the Tararua Range. Mr. Adams described the experience of a surveyor who has been engaged on the summits of this range in work which required a clear horizon in all directions. Under favourable circumstances the surveyor's task would have been completed in a few days, but he was so much hindered by clouds and haze that he had to pass a whole month on the range, and to take his observations in sections in such quarters as were from time to time free from obscurity.

2. "*Epalxiphora axenana*, Meyr., a species of *Lepidoptera* scarce in New Zealand" (illustrated), by Ambrose Quail, F.E.S. (*Transactions*, p. 343.)

3. "Notes on Ferns," by H. C. Field. (*Transactions*, p. 377.)

4. "A Revision of the Species of the *Formicidæ* (Ants) of New Zealand," by Professor D. A. Forel, of Chigny près Morges, Switzerland; communicated by Mr. A. Hamilton. (*Transactions*, p. 353.)

Mr. Cuthbert Freyberg gave an account of the variations of the barometer in Wellington during the few days immediately preceding the meeting. He exhibited the barograph tracings taken at the Colonial Museum during that period, and called attention to the peculiarities of the curves registered, the weather having been much disturbed throughout the time represented by the tracings.

THIRD MEETING: *6th July, 1904.*

Professor Easterfield, President, in the chair.

New Member.—Mr. Thomas Hunter.

The President informed the meeting, with much regret, that news had been received of the death of Mr. Robert McLachlan, F.L.S., one of the most distinguished honorary members of the New Zealand Institute.

Mr. G. V. Hudson said that the late Mr. McLachlan (who was elected an honorary member of the New Zealand Institute in 1874) was one of the greatest authorities in the world on the *Neuroptera*, and had done invaluable work in classifying the New Zealand species. His death was a very great loss to science, and would be widely deplored by entomologists and others.

Papers.—1. "On *Macro-lepidoptera* observed during the Summer of 1903–4, including a Note on the Occurrence of a Hawk-moth new to New Zealand," by G. V. Hudson, F.E.S. (*Transactions*, p. 358.)

2. "Notes on the Occurrence of some Rare Species of *Lepidoptera*," by A. P. Buller, F.E.S. (*Transactions*, p. 331.)

These two papers were discussed together. The President said that it was interesting to find that two collectors, working independently of one another, had each, within the same short period of time, observed so very rare a description of moth as the one referred to in the title of Mr. Hudson's paper.

Mr. A. P. Buller then exhibited a collection of butterflies made by Mr. Ward, naturalist to Sir Henry Stanley's expedition in search of Emin Pasha.

The thanks of the meeting were conveyed to Mr. Buller for his interesting exhibit.

3. "The Distillation of the Fatty Acids for the Manufacture of Candles," by P. W. Robertson, B.A. (senior scholar), F.C.S. (*Transactions*, p. 568.)

The Chairman congratulated Mr. Robertson on his researches, which had resulted in his bringing to light several matters, apparently not known before, in connection with the distillation of stearine.

FOURTH MEETING: *3rd August, 1904.*

Professor Easterfield, President, in the chair.

New Member.—Mrs. Ponsonby.

Papers.—1. "On Storm-routes in New Zealand,"* by R. A. Edwin, Retired Commander R.N. (*Transactions*, p. 555.)

2. "The Early History of the Morioris," by A. Shand (of the Chatham Islands); communicated by Professor H. B. Kirk. (*Transactions*, p. 144.)

This paper was read by Mr. E. Tregear. Mr. Tregear, in the course of some introductory remarks, pointed out that Mr. Shand was the sole repository of the knowledge of a lost race—the Morioris—therefore anything that he had to say upon the subject possessed a unique value.

The hour being late, the discussion of Mr. Shand's paper was deferred until the following meeting.

It was resolved that a letter should be sent to Mr. Shand thanking him for his valuable contribution.

FIFTH MEETING: *7th September, 1904.*

Professor Easterfield, President, in the chair.

New Member.—Mr. E. R. Dymock.

Auditor.—Mr. E. R. Dymock was elected Auditor to the Society for the current year.

Mr. Earp Thomas exhibited a tube of bromide of barium and bromide of radium which he had obtained from Madame Curie in February, 1901.

Mr. H. N. McLeod exhibited a spinthariscope.

On the motion of the Chairman, seconded by Mr. R. Coupland Harding, it was resolved, "That the Right Hon. the Premier of New Zealand be respectfully urged to make provision as soon as possible for having copies taken of the valuable manuscripts relating to the Polynesian race which were presented to the Cape library by the late Sir George Grey."

Captain Gilbert Mair, at the request of the Chairman, read a list of some of the more important of these manuscripts, and pointed out their extreme interest and their value to New Zealand. It was decided that a copy of this list should be sent to the Right Hon. the Premier along with the resolution.

Mr. A. Shand's paper on "The Early History of the Morioris" (read at the previous meeting) was then discussed.

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* (*a*) "The Meteorology of New Zealand: On the Routes of High and Low Pressure and the Changes of Pressure and Wind-movement resulting from them"; (*b*) "On the (probable) Mechanical Principle on which Atmospheric Circulation is based."

Captain Gilbert Mair explained how native traditions had been handed down, with the minutest details, for eight or nine hundred years. He read a narrative illustrating this.

At the invitation of the President, Captain Mair also read an abstract of a paper compiled in 1852 by a number of the oldest of the Morioris then living, dealing with the genealogy, early history, &c., of their people. (*Transactions*, p. 156.)

In the discussion which followed, Captain Mair mentioned that originally the Morioris were quite a distinct race from the Maoris, but that they appeared subseqently to have intermingled with the Maoris and formed with them a mixed race, introducing into their own language a proportion of Maori words. Some of the Morioris were of opinion that their ancestors had come from the Bay of Islands in New Zealand. There was no doubt that the Morioris were a most inoffensive race—they actually attacked the first Maori invaders of their territory with flax-stalks! At the present time (1904) there were only six pure Morioris surviving; in 1903 there were eight. He urged that immediate steps should be taken to secure photographs of the small remnant left.

Captain Mair exhibited a skull of a Moriori slave who was killed in 1839 or 1840.

Mr. A. H. Cockayne exhibited a photograph of a Chatham Island native, taken by Dr. Cockayne, of Christchurch.

Mr. H. H. Travers called attention to a paper read by him before the Philosophical Institute of Canterbury in 1865 ("On the Chatham Islands": *Transactions*, vol. i., pp. 119–127) embodying information which he had obtained, during a personal visit to the Chatham Islands in 1864, from the same source as that drawn upon by Mr. Shand.

Papers.—1. "Revision of the New Zealand Species of the Genus *Potamopyrgus*, with a Description of a New Species," by Henry Suter; communicated by Mr. A. Hamilton. (*Transactions*, p. 258.)

2. "Report on the *Mollusca* collected by Messrs. Keith Lucas and G. L. Hodgkin in Six Lakes of New Zealand," by Henry Suter; communicated by Mr. A. Hamilton. (*Transactions*, p. 233.)

Popular Lecture: *5th October, 1904.*

A lecture on "The Art Workmanship of the Maori People" was delivered by Mr. A. Hamilton, Director of the Colonial Museum, Wellington, on Wednesday, the 5th October.

The President, Professor Easterfield, occupied the chair.

The lecture (which was illustrated by a series of specially prepared lantern-slides) was open to the public. It was listened to by a very large audience.

A hearty vote of thanks, moved by Mr. Tregear and seconded by Mr. Justice Chapman, was accorded to Mr. Hamilton by acclamation.

SIXTH MEETING: *22nd November, 1904.*

Professor Easterfield, President, in the chair.

New Members.—The Right Rev. Dr. Frederic Wallis, Bishop of Wellington, Mr. E. Rudman, Mr. J. Cowan.

Papers.—1. Notes by R. Henry, of Resolution Island: (*a*) "On the Habits of the Conger-eel"; (*b*) "Irregularity of Fishes' Food"; (*c*) "On Moas and Wekas"; (*d*) "Traces of the Natives." Communicated by A. Hamilton.

2. "The East Coast Earthquake of 9th August, 1904," by G. Hogben, M.A. (*Transactions*, p. 421.)

3. "The Path of Earthquake-waves through the Earth," by G. Hogben, M.A. (*Transactions*, p. 424.)

4. "On the Fishing-dredges of the Maoris" (with exhibits), by Dr. A. K. Newman. (*Transactions*, p. 138.)

5. "On some New Species of *Lepidoptera*," by Alfred Philpott; communicated by G. V. Hudson. (*Transactions*, p. 328.)

6. "Revision of the New Zealand Species of the Genus *Isidora*, with Description of a New Sub-species," by Henry Suter; communicated by A. Hamilton. (*Transactions*, p. 267.)

7. "On the Site of Maupuia Pa, Miramar" (with exhibits of Maori weapons and tools), by H. N. McLeod. (*Transactions*, p. 171.)

8. "Some Hitherto-unrecorded Plant-habitats," by Dr. L. Cockayne; communicated by the President. (*Transactions*, p. 361.)

9. "On the Defoliation of *Gaya lyalli*," by Dr. L. Cockayne; communicated by the President. (*Transactions*, p. 368.)

10. "Notes on the Vegetation of the Open Bay Islands," by Dr. L. Cockayne; communicated by the President. (*Transactions*, p. 368.)

11. "On some New Species of *Macro-lepidoptera* in New Zealand," by G. V. Hudson, F.E.S. (*Transactions*, p. 355.)

12. "On the Construction of a Table of Natural Sines" (Part II.), by C. E. Adams, B.Sc. (honours). (*Transactions*, p. 202.)

Miss Mestayer exhibited a collection of Chitons.

Mr. A. Hamilton said that the collection (which was made in the neighbourhood of Wellington) was an exceptionally fine and complete one.

AUCKLAND INSTITUTE.

FIRST MEETING: *6th June, 1904.*

Professor A. P. W. Thomas, President, in the chair.

New Member.—Dr. Frengley.

The President delivered the anniversary address, taking as his subject "The Present Position of the Evolution Theory."

The address was copiously illustrated with lantern-slides and diagrams.

SECOND MEETING: *20th June, 1904.*

Professor A. P. W. Thomas, President, in the chair.

Professor H. W. Segar gave a popular lecture on "The Balance of Trade." (*Transactions*, p. 173.)

THIRD MEETING: *4th July, 1904.*

Professor A. P. W. Thomas, President, in the chair.

Papers.—1. "The Pollination of *Vitex lucens*," by D. Petrie. (*Transactions*, p. 409.)

2. "The Present Position of the Evolution Theory" (Part II.), by Professor A. P. W. Thomas

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FOURTH MEETING: *18th July, 1904.*

Professor A. P. W. Thomas, President, in the chair.

Dr. J. P. Frengley, Health Officer for Auckland, gave a popular lecture on "Progress in the Prevention of Disease."

FIFTH MEETING: *22nd August, 1904.*

Professor A. P. W. Thomas, President, in the chair.

New Members.—J. Henry, W. C. C. Spencer.

Mr. E. V. Miller delivered a popular lecture, illustrated by numerous experiments, on "Modern Views on the Conduction of Electricity."

SIXTH MEETING: *12th September, 1904.*

Professor A. P. W. Thomas, President, in the chair.

New Members.—C. Arnold, R. S. Florance.

Papers.—1. "Notice of the Occurrence of the New Zealand Hawk at the Cook Islands," by R. W. Gossett.

The writer stated that in April last he had shot on Manuae Island, one of the two Hervey atolls, comprised in the Cook Archipelago, a large hawk which he had no hesitation in referring to the common New Zealand Hawk (*Circus gouldii*). He had never seen a bird of prey on any of the Cook Islands before, nor was such an occurrence known to any of the residents, either native or European.

Mr. Cheeseman said that the New Zealand Hawk regularly visited the Kermadec Islands—presumably from New Zealand—every year at the time of the breeding season of the numerous petrels which frequented the Group.

Mr. J. L. Young asked if it was quite certain that Mr. Gossett's specimen had been correctly identified by him. He put the question because some years ago a South American hawk was introduced into Tahiti, and had become so numerous as to be a nuisance. It would be a comparatively short flight for some of these to cross from Tahiti to the Cook Islands.

2. "A Rare Saurian," by Archdeacon P. Walsh. (*Transactions*, p. 351.)

3. "A Flash of Lightning," by Archdeacon P. Walsh. (*Transactions*, p. 580.)

4. "Federation through Free Trade," by S. Gray.

5. "Notes on Ancient Polynesian Migrations to New Zealand," by Elsdon Best. (*Transactions*, p. 121.)

SEVENTH MEETING: *26th September, 1904.*

Professor A. P. W. Thomas, President, in the chair.

Professor F. D. Brown delivered a popular lecture, illustrated with numerous experiments, on "Mist."

EIGHTH MEETING: *27th February, 1905.*

Professor A. P. W. Thomas, President, in the chair.

New Member.—F. K. Thomson.

Papers.—1. "Notes on Fruit-flies, with a Description of a New Species," by Captain T. Broun. (*Transactions*, p. 325.)

2. "On some New Species of New Zealand Marine Shells," by Rev. W. Webster. (*Transactions*, p. 276.)

ABSTRACT OF ANNUAL REPORT.

The number of members on the roll at the present time is 160, of whom nine are life members and 151 annual subscribers. Six new members have been elected during the year—a number much below the average—and eleven names have been withdrawn (three from death, four from resignation, and four from non-payment of subscription for

more than two consecutive years. The Council would point out that the chief aim of the Institute—the maintenance of a free public museum for the instruction and entertainment of the people of Auckland—is one which appeals to the sympathies of all classes, and should command a liberal amount of support.

FINANCE.—The total revenue of the General Account, excluding the balance of £123 9s. 3d. in hand at the commencement of the year, has been £2,108 2s. 1d. In comparing this amount with that received during the previous year, it is necessary to bear in mind that it includes the two exceptional items of £1,000 (being the Government grant for the erection of the new hall) and £150 received on account of the Mackechnie bequest for the purchase of groups of large animals. Deducting these two sums, the ordinary revenue is seen to have been £958 2s. 1d., showing an increase of £85 3s. 6d. on the receipts for 1903–4. Of the separate items, the largest is the interest derived from the invested funds of the Costley bequest, amounting to £371 19s. Last year the receipts under this head were £357 10s. The Museum endowment, in rents and interest, has yielded £340 5s. 10d., a sum almost precisely equal to that of the previous year. The members' subscriptions show a slight decrease, although not one of any great moment. The remaining items call for no special remark. The total expenditure has amounted to £2,231 11s. 4d. It includes several items of an exceptional nature, the largest being the cost of the new hall, amounting to £1,082 2s. 3d., a sum considerably in excess of the Government grant. A payment of £147 7s. 3d. has been made in connection with the groups of large animals being prepared for the Museum, while the erection of the Maori house has drawn largely on the funds of the Institute. It has also been necessary to incur a considerable expenditure in repairs to the caretaker's house, and in alterations to the windows at the eastern end of the main hall. Adding all these payments to the ordinary expenditure required for the maintenance of the institution, the year's operations show a debit balance of £29 7s. 6d. There is no change of importance with respect to the invested funds of the Institute, the total amount of which is £16,263 12s. 5d., showing an increase of £36 9s. 3d. during the year.

MUSEUM.—The register kept by the janitor shows that the total number of visitors on Sundays has been 13,716, or an average of 263 for each Sunday. The greatest attendance was 474, on the 12th February; the smallest 91, on the 31st July. For the six principal holidays of the year —New Year's Day, 2nd January, Good Friday, Easter Monday, King's Birthday, and Boxing Day—the total attendance was 1,869, being an average of 313 for each day. On week-days the visitors can only be occasionally counted, and the attendance varies so much, according to weather and other circumstances, that it is not easy to form a reliable estimate, but the average daily attendance cannot be far from a hundred. This would make a total of 30,700, or of 46,285 for the whole year. Last year the estimated number was 45,360. A hall 50 ft. square has been erected in the space between the statue-hall and the main hall. One-half has been reserved for the Maori carved house, Rangitihi, which is now being erected on it; the other half will form an exhibition gallery for foreign anthropological specimens. The total cost of the building, including architect's fees and all other expenses, has been £1,082 2s. 3d., the surplus over the Government grant being provided for out of the ordinary revenue of the Institute. The Council trust that the present year will see the completion of a new and important exhibit in the shape of the Maori house Rangitihi, the carvings of which have been in their possession for several years past. A start was made with its erection immediately after the completion of the new hall, and the elaborately carved side-posts are now all in position. The ridge-post, together with the central post, or poutokomanawa, has been set up, and the rafters are now being prepared. Arrangements are now being made for obtaining

the large supply of kakaho or reeds which will be required for the roof and verandah of the house. The huge gable-boards, or maihis, which were unfortunately wanting when the house was purchased, have been carved at Rotorua by an experienced Maori carver after old designs, the work being superintended by Mr. C. E. Nelson, whose intimate knowledge of Maori handicraft is a guarantee that it has been well executed. Members are aware that the late Mrs. Mackechnie bequeathed a sum of £500, to be expended, at the discretion of her executor, in suitable additions to the Museum. This gentleman decided that the bequest should be devoted to the purchase of stuffed groups of the larger animals, set up in the best style of taxidermy, and protected by plate-glass cases. The first of these groups, consisting of a male and female lion and four cubs, has been received during the year, and has been placed in the main hall, to which it forms a great attraction. A companion group, comprising a male and female tiger and a leopard, is now on its way from England, and may be expected at any time. A third group has been arranged for, and the funds will probably be sufficient to obtain a fourth. In last year's report it was stated that the Mackechnie bequest of £2,000 had been received and invested, and that in future an annual income of about £100 would be available for the purchase of books for the library. The Council have consequently been able to order two consignments from their London agents. The first of these arrived some months ago; the second is now on its way from England. Funds will shortly be available for another shipment; in fact, the regular purchases which can now be made will enable the Council to extend the library in a manner which could not be attempted out of the ordinary revenue of the society. With the quicker growth of the library the question of additional accommodation will soon require consideration. The Council have to report that the connection of the Institute with the maintenance of the Little Barrier Island as a sanctuary for the preservation of the avifauna of New Zealand, which has existed since the beginning of 1897, is now about to close, the Government having intimated that the Tourist Department will assume direct control at the end of the financial year, on the 31st March. The Council claim that during the eight years the island has been in their charge the visits of collectors have been effectually stopped, and that no unauthorised persons have been allowed to land; that the stock left upon the island by the Maori owners has been removed, and that their visits have consequently ceased; and that wild cats and other vermin have been shot or otherwise destroyed. The result of these measures is seen in the fact that birds of all kinds are much more numerous than when the island was first acquired, and are more generally distributed, even breeding in large numbers on the flat, close to the Curator's house. The Council much regret the change, and would point out that in removing the management of the island from the Institute the Government are losing the services of a local body whose sympathies and inclinations are all on the side of the preservation of the fauna of New Zealand, and who can command the expert knowledge that is required, whereas it cannot be said that the Tourist Department possesses any special qualifications for the work.

Election of Officers for 1905.—*President*—Professor A. P. W. Thomas; *Vice-Presidents*—Dr. E. Roberton and J. Stewart, C.E.; *Council*—L. J. Bagnall, Professor F. D. Brown, H. Haines, J. H. Howell, J. Kirker, E. V. Miller, T. Peacock, D. Petrie, J. Reid, Professor H. W. Segar, J. H. Upton; *Trustees*—T. Peacock, J. H. Upton, Professor F. D. Brown; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.; *Auditor*—W. Gorrie.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

FIRST MEETING: *4th May, 1904.*

Dr. Charles Chilton, President, in the chair.

The President welcomed Messrs. Hodgson, Armitage, and Morrison, of the National Antarctic Expedition, who were present.

The President also announced the arrival of copies of the "Index Faunæ Novæ-zealandiæ," and on behalf of the Council of the Canterbury Institute, and of the Council of the Otago Institute, and of the various contributors to the Index, presented Captain Hutton (the editor of the Index) with a bound volume of congratulatory letters on the occasion of its publication.

The President read the presidential address on "Arctic and Antarctic Faunas."

Mr. F. V. Hodgson exhibited some marine zoological specimens from the extreme south.

Lieutenant Armitage exhibited the instruments from the "Discovery" for the determination of the magnetic elements at sea.

Dr. Farr exhibited a parallel series of curves obtained by Mr. Bernacchi in Antarctica and at the Magnetic Observatory, Christchurch.

SECOND MEETING: *6th June, 1904.*

Dr. Chilton, President, in the chair.

New Members.—Mr. O. B. Pemberton, Rev. A. C. Hoggins, J. S. Tennant, C. J. Sloman, F. V. Hodgson, H. G. Denham, J. J. Collins, Dr. J. Stevenson, Captain F. M. B. Fisher, E. Stead, Dr. H. M. Inglis, J. Hight, Miss Freeman, and Miss Fodor.

Address by Mr. L. Birks, A.M.Inst.C.E., on "An Electrical Engineer's Visit to Switzerland."

THIRD MEETING: *6th July, 1904.*

Dr. Chilton, President, in the chair.

New Members.—Rev. C. H. Moreland, Dr. A. G. Talbot, Mr. E. M. Sandstein, and Mr. Alaster Wright.

Address.—Mr. Cyrus Williams, M.Inst.C.E., gave an address on the "Artesian System of Queensland."

FOURTH MEETING: *3rd August, 1904.*

Dr. Chilton, President, in the chair.

New Members.—Dr. B. M. Moorehouse, Dr. Gibson, and Mr. C. D. Hardie.

Papers.—1. "A Revision of the Tertiary Brachiopods of New Zealand," by Captain Hutton. (*Transactions*, p. 474.)

2. "Three New Tertiary Shells," by Captain Hutton. (*Transactions*, p. 472.)

3. "A Revision of the New Zealand Species of *Ceramiaceæ*," by R. M. Laing. (*Transactions*, p. 384.)

4. "Campbell Island Rocks," by R. Speight. (*Transactions*, p. 552.)

FIFTH MEETING: *7th September, 1904.*

Dr. Chilton, President, in the chair.

New Member.—Mr. C. Aschmann.

Address.—Mr. G. Gray, F.C.S., delivered an address on "Plant-food."

SIXTH MEETING: *5th October, 1904.*

Dr. Chilton, President, in the chair.

Address.—Mr. R. M. Laing, M.A., B.Sc., delivered an address on "Radio-activity."

SEVENTH MEETING: *2nd November, 1904.*

Dr. Chilton, President, in the chair.

New Members.—Mr. F. W. Terry, Mr. Hülsen, and Mr. F. Stone.

Papers.—1. "On the Occurrence of the Shrike Thrush in New Zealand." (*Transactions*, p. 350.)

2. "On the Formation of the Canterbury Plains," by Captain Hutton. (*Transactions*, p. 465.)

3. "List of Tertiary *Mollusca* in the Canterbury Museum," by Captain Hutton.

4. "Appendix (1) to the List of New Zealand Seaweeds," by R. M. Laing. (*Transactions*, p. 380.)

Dr. Chilton exhibited the disarticulated skull of a wallaby.

Dr. Farr exhibited some curves relating to the electrical condition of wind, particularly of nor'-westers.

ANNUAL MEETING: *30th November, 1904.*

Dr. Chilton, President, in the chair.

New Members.—Mr. J. E. L. Cull and Mr. Iredale.

ABSTRACT OF ANNUAL REPORT.

The Council has met eight times since the previous annual meeting. Out of ten members the average attendance has been 7·5.

The "Index Faunæ Novæ-zealandiæ" has been completed. The price at which the volume was originally issued to subscribers has now, as always contemplated, been raised to 12s. 6d. The Index not only supplies a much-felt want, but its publication has also been financially satisfactory.

The safe return of the National Antarctic Expedition to Christchurch is a matter for congratulation, and marks an epoch in the history of southern exploration. During the stay of the vessels in port several of the officers frequently attended the meetings of the Institute, and exhibited their instruments and some of their specimens.

It had been hoped that the reconstitution of the New Zealand Institute would result in the earlier appearance of the annual volume of Transactions. This has so far not been the case.

The library has been maintained in an efficient condition, and thirty pounds' worth of books have recently been ordered from England. A proposal has been made to issue a joint catalogue of scientific books, magazines, and pamphlets in the libraries of the Museum of the Canterbury College and of the Philosophical Institute.

The number of members has increased from eighty-five to 105, and there has been an average attendance at the meetings of forty-one.

Five addresses have been given during the year, and nine papers have been read.

The balance-sheet shows a credit balance of £53 1s. 2d., whilst the accumulated funds arising from the subscriptions of life members now amount to £85 3s. 9d.

The Council regrets that owing to his removal to Wellington it has lost the services of Dr. Cockayne.

Papers.—1. "On Some Glaciated Stones from Queenstown, Lake Wakatipu," by Mr. E. G. Hogg. (*Transactions*, p. 426.)

Mr. Hogg remarked that the specimen exhibited by him appeared to be the first found in New Zealand.

2. "On the Occurrence of a Species of *Cercaria* on the Cockle," by Dr. Chilton. (*Transactions*, p. 322.)

3. "On the Function of the Last Pair of Legs in *Grimothea gregaria* (Whale-feed)," by Dr. Chilton. (*Transactions*, p. 320.)

Dr. Chilton exhibited living specimens of *Lepidium viridis*.

OFFICERS FOR 1905.—*President*—Dr. Coleridge Farr; *Vice-Presidents*—Mr. R. Speight and Mr. F. W. Hilgendorf; *Treasurer*—Professor Charles Chilton; *Council*—Captain F. W. Hutton, Dr. W. P. Evans, Messrs. J. B. Mayne, R. M. Laing, A. E. Flower, and Dr. Talbot; *Honorary Auditor*—Mr. G. E. Way.

OTAGO INSTITUTE.

First Meeting: *10th May, 1904.*

The President, Professor W. B. Benham, read his presidential address.

The President, after returning thanks for the honour done him in electing him to the office of President for another year, said that since the last presidential address was delivered the Institute had sustained the loss of two valuable members of its Council—Mr. Justice Chapman and Mr. A. Hamilton. Both gentlemen have been valued coadjutors in the Council's affairs. It was frequently complained that the meetings were "dull," and in order to render them less dull, and even interesting, discussions of papers and casual talks on various subjects of interest would be welcomed. These two gentlemen were always ready to join in such discussions and to give such casual talks. There were, unfortunately, few members—lay members, if he might so express himself to distinguish them from the few professional scientists—who were so ready to give their opinions as those two were. One often hears it stated that in former days —in the good old days when the Institute was young, it was vigorous too —its meetings were interesting, the papers more varied and less abstruse, and so forth. It had sometimes occurred to him that a possible means of revival of that much-to-be-desired condition of affairs might be attained if they made it a rule that no professor or lecturer —*i.e.*, no professional—should read a paper or even be present at the meetings. Let them lay their papers on the table for publication in the Transactions, but let the evening meetings be conducted by "lay members." It had occurred to him that then, perhaps, younger folk would be induced to bring forward matter for discussion. In their programme for the present session they had, as members would be glad to note, two or three "new performers" in the lecture-room. It was a very general, but wholly erroneous, idea that the Institute was mainly connected with science; but that was not so. The laws of the Institute referred to the "promotion of art, literature, philosophy, and science," and yet it had come about that science, at any rate in recent years, had predominated in the agenda lists, and that biology, perhaps, had till the last year or two taken the lead. Was there no advancement in art, literature, or philosophy? Where were their literary and philosophical members? Was it that the folk who were interested in these matters preferred to keep their ideas to themselves? Why was it that only scientific men, or chiefly so, attended and read their articles? Were they to conclude from this absence of votaries of arts, literature, and philosophy, and the presence of scientific men, that it was only science and its followers that were awake, alive, and active? It might be that there were societies for arts, literature, and philosophy; if so, they seemed to hide their light under a bushel. In any case, it would be a pleasing change if some of their members were to discourse on some of these subjects at their meetings. Since their last meeting two important events in the scientific world had occurred. The first was the meeting of the Australasian Association for the Advancement of Science, which met for the first time in Dunedin, and for the second

time of its existence in New Zealand. The success of the gathering was due primarily to the energy and labour of the local secretary, Mr. G. M. Thomson—(applause)—and also to the activity of the various business men of the city, who willingly gave up their time, and acted on the different sub-committees to which was intrusted the work of entertaining the visitors. The second event was the safe arrival of the "Discovery," with the welcome news of "All well on board." Biologically, the most important fact ascertained was that fossil plants occurred in the sandstone of the continental plateau, which rose to a height of 8,000 ft. or 9,000 ft. This added one more piece of evidence in favour of the view already put forward by several Australasian biologists that Tierra del Fuego extended further south at some earlier geological period than it did at present, and connected with an antarctic continent, which in its turn was continuous with New Zealand or Australia. But in order to judge of the period and character of this great land they must wait till the rocks gathered by the expedition had been examined. Nevertheless, those already collected by Borchgrevinck and previous explorers indicated a similarity, if not identity, with some of the rocks of Victoria. As the subject was suggested for discussion at one of their meetings, he would reserve further remarks on the importance of the results until that occasion. After referring to the completion of the marine-fish hatchery at Portobello, and to the attempts in January last to investigate the floor of the continental shelf round this colony, the President spoke of a number of scientific works recently completed in New Zealand, among which he mentioned Captain Hutton's "Index to the Fauna of New Zealand" and "Natural History of New Zealand," and Mr. Hudson's "Neuroptera." He then turned to a more special matter, and considered the utility of the study of zoology and botany, and in an interesting account of work carried on in both subjects he showed many serviceable results that were being daily achieved by investigators. One had only to refer to the bulky annual report of the Department of Agriculture to note the variety and the value of the investigations carried on by the Government biologists. The study of the life-histories of insects and other creatures—especially those that attacked the various kinds of fruit-trees, timber-trees, of cereals, and so forth—enabled the zoologist to suggest remedies or preventives. So, too, with regard to the various parasites that affected cattle. The proper treatment of the disease necessitated a knowledge of the cause, and this in turn demanded a scientific study of the organism that in many cases was the cause of the trouble. He proceeded to deal at length with some of these parasitic diseases and with the biological work required in treating them, making special reference to the cause of malarial fever, sleeping sickness, and other ailments, and the remedies which, after investigation by scientists, have been adopted to counteract some of them.

At the conclusion of the address, which occupied an hour and a half in delivery, Mr. J. C. Thomson proposed a vote of thanks to Dr. Benham for his lucid and instructive remarks, which was carried with applause.

New Member.—Mr. E. Herbert.

SECOND MEETING: *3rd June, 1904.*

Dr. Marshall exhibited a spindle-shaped stone implement that had been found in a rock-cleft during excavation-work at Musselburgh, also specimens of pitchblende and radium.

During the evening three speakers dealt with different phases of the results of the "Discovery" expedition.

Dr. P. Marshall took up the history of discovery in geography and geology, and gave some details of the voyages from the finding of the South Shetlands in 1599 to the second year of the Scottish expedition, which was first reported on the 31st May of this year. He laid particular stress upon Cook's voyage in 1744, and Ross's in 1839–43, and mentioned that each of the voyagers considered that a southern continent existed, owing to the numerous large flat-topped icebergs consisting of inland ice that they encountered in every longitude. He mentioned that fossils had been discovered by the Swedish expedition in Graham Land that were probably vegetation indicating a tropical climate, and also some land-animals. Mr. Ferrar, of the "Discovery," had found leaf-fossils at an elevation of 6,000 ft. in south Victoria Land. The existence of volcanoes in south Victoria Land and Graham Land seemed to point to a connection between the great volcanic land of South America and a Pacific line through New Zealand.

Mr. J. S. S. Cooper spoke of what had been done by the expedition in physics. He referred to the very cold weather experienced, the register being at times 68° below zero, which was much colder than anything experienced in the Arctic regions. Pendulums were swung in order to discover the force of gravity, and the results would have an important bearing on the theories as to the shape of the earth. Important findings were also made in atmospherical electricity. A very complete set of apparatus sent down was checked in Christchurch before it went away and after it came back. It was owing to the liberality of the New Zealand Government in providing a magnetic observatory at Christchurch that Lyttelton was made the base of the expedition. One curious thing he mentioned—namely, in the western sledge journey Lieutenant Shackelton got to the south of the south magnetic pole, so that his magnetic needle pointed in an exactly contrary direction to that in which it should point, the north end pointing south. A suspended needle pointed almost vertical, the horizontal force being practically nothing. Mr. Cooper exhibited curves taken by Mr. Bernacchi, and compared them with curves taken at the same time in Christchurch and Germany. On corresponding days they showed similar characteristics, thus proving that the disturbances recorded had been felt all over the world at the same time. A great magnetic storm in November, 1903, which largely deranged the telegraphic system of Europe, was clearly recorded at Christchurch and by the "Discovery" party.

Mr. G. M. Thomson touched on the biological work of the expedition. There were, he said, several remarkable differences between the Arctic and Antarctic regions. The former had quite a rich flora, including a large number of flowering-plants, and numerous mosses and lichens. In short, in the Arctic summer of a few weeks' duration the sheltered parts were full of verdure and beautiful flowers—poppies, buttercups, white scurvy-grass, purple saxifrages, and others—with beds of green grass in many places. The mosses—green, red, and brown—occurred in large beds wherever there was moisture, and the dead moss formed masses of peat. The rocks were everywhere covered with many-coloured lichens. Thus the whole aspect was varied and warm-coloured. But in the Antarctic there were no flowering-plants whatever, very few lichens, and still fewer mosses. There being no plant-life, there was none of the insect-life such as was always associated with plants. The invertebrate fauna were all obtained within the 100-fathom line. There was no littoral or tidal zone, because the shore was mostly hidden under a permanent ice-face. The "Gauss" found much the same. The coast, where accessible, was covered with an ice-face, and elsewhere was precipitous and inaccessible, and falling steeply to a deep sea. The most interesting discovery of all, perhaps, was that made by Mr. Ferrar, who accompanied Captain Scott on his western journey. A great

glacier, filling the valley, was followed for about eighty miles to a height of 9,000 ft., where it joined the inland ice. On the edge of this inland ice he found fossil leaves in a bed of sandstone of the Tertiary age. These fossils were not yet worked out, but included Dicotyledons, which pointed to a warmer climate.

A vote of thanks was accorded the speakers for their interesting contributions.

Third Meeting: *19th July, 1904.*

Professor Evans delivered an address on "Photography in Colour."

The process in hand might, he said, be called "the reproduction of certain effects of light by means of certain other effects of light." What, then, was light? He could not tell them. All he could say was that, just as the clearest views of the phenomena of sound were reached when we imagined them as caused by wave disturbances passing out from sonorous bodies, so was the most comprehensive understanding of the phenomena of light reached if we looked upon it as wave disturbances passing out in all directions from luminous bodies. He went on to explain the science of light, and illustrated his remarks by projecting, by means of a powerful limelight, a white light on the wall, showing that white light was made up of many other colours by inserting a prism and throwing the reflection of the visible spectrum on the wall. He then spoke at some length on the wave theory of light, and illustrated the wave-lengths by means of diagrams thrown on a screen by a lantern. The problem of colour-photography was as old as photography itself. All attempts to solve it could be divided into two groups—they prepared light sensitive surfaces, which retained the colour of the light to which they were exposed, or they produced ordinary photographic pictures, which were coloured and then superposed to obtain the desired effect. The first might be called the direct, and the second the indirect method. The earliest partly successful applications were those of Becquerel, St. Victor, Seebeck, and Poiterin. The two first named covered a highly polished silver mirror with a thin layer of silver-chloride, and exposed it to the light until the delicate surface was converted to the brown sub-chloride. By projecting the solar spectrum on the prepared surface good coloured impressions were obtained. Poiterin substituted paper for the silver substratum, but no other substance had been found that could replace the silver-subchloride. The method and the coloured image given by that substance were not permanent; the image was destroyed by further exposure to light; and, despite numerous experiments, no chemical had been discovered that could fix the subchloride without destroying the colour. A light sensitive substance could only be altered by those coloured rays which the substance absorbed; red light would have no effect on a red body, green rays no influence on a green body. He illustrated these facts by experiments with the lights thrown on the wall, and, after exhibiting slides of photographs of various coloured flowers, showing how the different blossoms had been brought out more prominently by the use of different coloured screens in the photographic process, he went on to explain the different wave-lengths of the lights, and the impressions of photographs taken by the human eye, illustrating the latter with an optical delusion. Continuing, he said that, though the ear could distinguish the different notes in a chord, the eye did not distinguish between the colours forming one composite colour. Upon that inability most of the theories of colorisation were based. With the normal eye all the possible colour-sensations could be given

by red, green, and violet (or blue-violet) mixed in proper proportion. He then went on to explain the three sets of nerves in the eye, and the sensation caused by the colours on the three nerves, after the Young-Helmholtz theory. The primary colour-sensations were red, green, and violet. Throwing discs of the three colours on the wall, he showed that red and green together produced yellow, violet and red produced a purple, and green and violet produced a bluish green. By superposing the red, green, and violet a fair white light was produced. He then projected the picture of an ordinary photograph on the wall, and by superposing the three coloured discs in front of it the photograph stood out in natural colouring, the result being received with prolonged applause. Various pictures were shown in the same manner, including a beautiful sunset view, the red flush in the sky, the gold tinting of the clouds, and the blue and green of the sea being seen to perfection. He stated that not one of the negatives had been retouched, but were simply taken through three coloured screens, and then projected through three coloured glasses. Was it not possible to do away with the complex triple lantern and superpose the three photos permanently? Certainly it was, and that was just how the many modern beautiful reproductions of oil and water-colour paintings were being formed. By placing the three screens in the front of one lens there would simply be a subtraction and consequent darkness instead of light. Evidently, if they wanted to reproduce in colour, they must make three gelatines and stain them, and use complementary colours, so that each film would receive certain rays only. The method was to take the three negatives from the three-colour screens and then form three printing-blocks. The lecturer then explained the technique of the printing-block colours, and concluded by saying that the practical part of this process consisted of the decomposition of the original colours and the printing. The problem of colour-decomposition by photographic means could be considered as solved, as by employing different sensitive and light filters the condition of sensitiveness could easily be regulated; but the recomposition of the three-colour pictures by the means of printing left much to be desired. The production of the photo-mechanical printing-surfaces was uncertain, and the printing process itself lacked that uniformity which three-colour printing required.

The lecturer was tendered a hearty vote of thanks at the close of his address.

FOURTH MEETING: *9th August, 1904.*

Professor Scott gave an address on "Primitive Man," illustrating his remarks by the exhibition of numerous models.

The President, Professor Benham, exhibited "ski" that had been used by members of the "Discovery" Antarctic Expedition, also a fossil crab from Waipara, and a fossil crayfish from Ahuriri.

Papers.—1. Mr. G. M. Thomson: A Paper by Mr. J. A. Thomson, B.Sc., "On a Small Salt Pool in the Barewood District."

2. "On *Pecten huttoni*," by Professor Park. (*Transactions*, p. 485.)

3. The President contributed a paper by Mr. W. Dunbar "On the Skull of *Regalecus parkeri*."

New Members.—Messrs. A. Bowman, C. W. Hay, and F. W. Payne.

FIFTH MEETING: *13th September, 1904.*

The President, Professor Benham, exhibited specimens of the emperor penguin from Victoria Land, and of a nestling albatros (*Diomedea regia*), and of *Ramulina* which had been dredged near Otago Heads.

Mr. G. M. Thomson exhibited a collection of dried specimens of *Mycetozoa.*

Papers.—1. "The Genesis of Ore-deposits," by Professor Park.

2. "The Marine Tertiaries of New Zealand," by Professor Park. (*Transactions*, p. 489.)

3. "Border Segregation of Igneous Masses," by Professor Park. (*Transactions*, p. 486.)

4. "Some Olivine Rocks from Milford Sound," by Dr. Marshall. (*Transactions*, p. 481.)

5. "Some Earthworms from the North Island," by Professor Benham. (*Transactions*, p. 281.)

6. "Some Earthworms from the Southern Islands," by Professor Benham. (*Transactions*, p. 285.)

7. "Note on *Ramulina globulifera*," by Professor Benham. (*Transactions*, p. 300.)

Mr. G. M. Thomson led a discussion on the metric system, and the President, Mr. Justice Chapman, Messrs. Skey, Payne, Fels, McPhee, and Professor Park took part in it.

SIXTH MEETING: *11th October, 1904.*

Dr. Benham, the President, exhibited some excellent photographs of various species of New Zealand *Phasmidæ.*

Dr. Benham read a paper entitled "Notes on Dr. Bergh's Diagnosis of certain New Zealand Nudibranchs." (*Transactions*, p. 312.)

Mr. R. Gilkison read a most interesting paper on "The Treatment of Crimes and Criminals."

He strongly advocated the classification of criminals, and outlined the methods that had been adopted in America and elsewhere with this object.

The lecture aroused much interest, and several members took part in the discussion that followed.

SEVENTH MEETING: *8th November, 1904.*

Dr. Hocken exhibited two of the medals that were struck to commemorate Captain Cook's second voyage.

The President exhibited the natural cast of the brain of an extinct species of whale.

Papers.—1. "The Geology of Dunedin," by Dr. Marshall.

Dr. Marshall dealt with the physiography and development of the surface features as well as with the details of the interesting alkaline igneous rocks of the locality.

2. "Further Notes on Sipunculids," by Professor Benham. (*Transactions*, p. 301.)

3. "On Earthworms from the Kermadecs," by Professor Benham. (*Transactions*, p. 298.)

4. "The Occurrence of Large Masses of Ferrous Sulphate in Gold-mines," by Mr. M. Paul; communicated by Professor Park. (*Transactions*, p. 551.)

The annual meeting was then held.

The report of the Council for the past year was read.

The Council has remained unchanged since its election in November, 1903, but a cordial welcome was extended to one of its members, Dr. Hocken, on his arrival from an extended visit to Europe.

During the session four new members were elected, three resigned, one deceased, and eight were struck off the roll for non-payment of subscription. This is a reduction of eight members, so the total is now reduced to 104.

Two items of extraordinary expenditure appear in the balance-sheet. The one is an amount of £50, which is the balance of the sum promised by the Institute to the marine-fish hatchery. The Council was represented at the opening of the institution, and the representatives were thoroughly satisfied with its equipment, and have every confidence that valuable economic results will accrue from its establishment. The second large payment is a sum of £25 for the purchase of fifty copies of the "Index Faunæ Novæ-zealandiæ." The work was published at the expense of the Canterbury Philosophical Institute, and the sum named above represents the amount of financial assistance that your Council felt justified in granting towards the expenses incurred in publishing this highly important work. The Council regrets that the other affiliated institutes did not contribute towards the expense of publication.

The lecture given by Professor Evans, of Canterbury College, was delivered in the Stuart Hall, and proved highly interesting. The Council thinks that the practice of inducing prominent scientific men in other centres to give lectures has proved so successful that it should be continued.

The new constitution of the New Zealand Institute came into operation during the past year. The Council considers that this direct representation greatly increases the benefits that the local institutes derive from the central body.

The balance-sheet, duly audited, was adopted. The receipts for the year, including a balance of £34 11s. 11d., amounted to £143 6s. 2d., and the expenditure to £267 16s. A sum of £150 was withdrawn from deposit to meet this expenditure, and a balance of £25 10s. 2d. remains at the Union Bank.

Election of Officers for 1905.—*President*—Mr. J. C. Thomson; *Vice-Presidents*—Professor Benham, Dr. T. M. Hocken; *Council*—Messrs. A. Bathgate, E. E. Collie, Dr. Fulton, Dr. Marshall, Professor Park, Messrs. G. M. Thomson and D. B. Waters; *Hon. Secretary*—Mr. R. Gilkison; *Hon. Treasurer*—Mr. W. Fels.

WESTLAND INSTITUTE.

ANNUAL MEETING: *14th December, 1904.*

The President (Mr. McNaughton) in the chair.

ABSTRACT OF ANNUAL REPORT.

In presenting this report to the members the Trustees hope that they may give a fairly good account of the position of the society. While not ignoring the many obstacles that beset its path, they have endeavoured to avoid anything that might have acted as a drawback to its welfare. The year has been somewhat of a stationary one, in some things of a retrograding nature, and therefore points out to us that there is something required to aid the society's welfare, and that time will probably solve the problem and bring about that improvement. In the meantime the Trustees have done the best with the means at their command, and, as all our predecessors found, the financial question was the most acute, and has been so from its advent, and will remain so to the conclusion.

The Honorary Treasurer will lay before you the balance-sheet, which discloses that a certain amount of the liabilities and urgent accounts have been met; but the outstanding demands will have to be met by a special vote of the meeting.

Subsidies received from Government grant, Borough Council, and Harbour Board, amounting to £37 2s. 3d., have been a welcome addition to the funds, and the Trustees desire to record their thanks for the same.

The members' roll contains sixty names, which include honorary and junior ones.

The library has been well patronised during the current year, especially on Saturday evenings. The selection committee has well supplied a number of new and popular works, about a hundred volumes having been added, mostly fiction. There has been a demand for other works of a higher standard, but they are beyond the income of the Society.

The reading-room is well supplied with the leading dailies and local papers, which are donated to the room, and the Trustees desire to record their thanks in this report to the proprietors for the same.

The usual number of Government papers, including reports of the Lands and Survey Offices and the Tourist Department, have been received, and also the *Mines Record*, for which they convey their thanks to the departmental officers concerned.

The committee meetings during the year have been well attended, and all business has been satisfactorily arranged.

In the matter of the application for a grant to Mr. Carnegie, it is still in abeyance, the society not having received any word of its success or refusal.

The Museum is still popular as one of the sights of the town, and strangers frequently visit the same.

The retiring Trustees beg leave to convey their thanks to the members for their courtesy and assistance during the year, and to state that

there have been no extra expenses during the year, the principal liabilities being for books, which are good assets, and for papers, which are a necessary formula of the Institute, but which have a tendency to diminish income with very little return. They conclude with a hope that the incoming Trustees may have a prosperous year.

The annual report and balance-sheet were read and adopted.

It was reported that the membership numbered sixty, including junior and honorary members; that £37 had been received during the year in subsidies; that the receipts for the year were £104 14s. 1d., and the expenditure £95 6s. 3d., leaving a credit balance of £9 7s. 10d.; that the matter of the Carnegie subsidy was still in abeyance; and that over a hundred volumes of various new works had been added to the library during the year.

Votes of thanks were passed to the retiring officers, local newspapers, and to all other benefactors of the Institute.

ELECTION OF OFFICERS FOR 1904.—*President*—Mr. Mabin; *Vice-President*—Mr. G. Perry; *Treasurer*—Mr. D. Macandrew; *Trustees*—Messrs. Michel, Morton, Beare, Dunne, Clarke, Lewis, Park, McNaughton, Heinz, Mahan, Wilson, and Dr. Teichelmann.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

Annual Report.

During the past year there have been, including the annual business meeting, seven meetings of the Institute. The Council met seven times, and transacted a large amount of general business. At the ordinary meetings four lectures were delivered and six papers read.

The library has been increased by twenty volumes, and the accommodation for the books has been much improved. The Institute is deeply indebted to Mr. Pointon, who has erected a new lantern-gallery, which has added greatly to the convenience and comfort of those who work the lantern.

In September last Mr. A. Hamilton withdrew from the Museum a large number of his Maori curios. His remaining curios, together with a number of botanical specimens, Mr. Hamilton presented to the society.

The botanical specimens of the late Mr. Colenso, which had been lent to Mr. Cheeseman, of Auckland, were returned by that gentleman properly classified and arranged. Mr. Hill was authorised to communicate with the Government with a view to the specimens being placed on deposit in the Colonial Museum, where they would be of considerable use for scientific purposes. Acting on the recommendation of the Council, Mr. Hill communicated with the Premier, with the result that the specimens have been forwarded to Wellington and placed on deposit as suggested.

Early last year a sub-committee was appointed to consider the question of arranging the specimens and putting the Museum in order generally. Nothing, however, has been done in this direction; but your Council consider the matter should be dealt with at once, if the Museum is to be of any use to the society or to the public.

Four new members were elected during the year, making a total membership of fifty-five.

List of Papers read during the Session, 1904.

May 2.—The President, Dr. Moore, delivered the inaugural address, his subject being "What we know about Alcohol."

June 7.—Lecture by Dr. Kennedy, "Star-gazing without a Telescope," illustrated by a large number of lantern-slides.

July 4.—Joint lecture by Messrs. Tanner and Hill, "The Hot Lakes District," the former taking the northern part and referring particularly to the Waimangu Geyser; the latter dealing with the southern portion, with special reference to Ruapehu and the nature of volcanoes. Numerous lantern-slides were used in illustration.

September 19.—Lecture by Mr. Hill, "The Making of the Heretaunga Plains and Artesian-water Basins," illustrated by lantern-slides. Seismograph records were shown by Mr. Hogben.

October 17.—Paper by Mr. Dinwiddie, "Herbert Spencer."

November 21.—Papers by Mr. Taylor White, (1) "On the word 'Moa'"; (2) "Notes on Ants."

ELECTION OF OFFICERS FOR 1905. — *President*—H. Hill, B.A., F.G.S.; *Vice-President*—H. W. Antill; *Council*—W. Dinwiddie, T. Hall, E. A. W. Henley, M.B., F. Hutchinson, jun., T. C. Moore, M.D., T. Tanner; *Hon. Secretary*—Jas. Hislop, district school; *Hon. Treasurer*—J. W. Craig; *Hon. Auditor*—G. White; *Lanternist*—C. F. Pointon.

NELSON INSTITUTE.

Annual Report.

The committee have much pleasure in presenting to members of the Institute the annual report and balance-sheet for the past year.

The receipts for the year from all sources amounted to £279 6s. 3d., and the expenditure to £269 14s. 5d., leaving a credit balance of £9 11s. 10d. It will be noted with satisfaction that the receipts from subscriptions amounted to £175 4s. 3d.—an increase of £28 7s. 5d. over last year. The number of subscribers on the books is 235—180 annual subscribers, fifty-five half-yearly, and fifty quarterly.

About 180 volumes of new works have been purchased during the year, the selection including, in addition to fiction, a proportion of works on general literature, travel, science, biography, &c., with the view of making the Institute useful for general literary and educational purposes, as well as providing for those who prefer lighter literature. The committee have also purchased the latest edition of new volumes of the "Encyclopædia Britannica," at a cost of £11 10s. Several new magazines and periodicals have been added during the year, and members now have the advantage of a large and varied selection of the best illustrated papers, reviews, magazines, and periodical literature.

The lessee of the Gordon Accommodation-house Reserve has complied with the improvement conditions of his lease to the satisfaction of the committee.

With regard to the Tadmor land, the committee have thought it best to defer dealing with it until the section of railway now in progress is completed, when it is hoped the millable timber can be disposed of to advantage and the land let on lease.

The free reading-room has been well attended by the public, a large number of readers frequenting it during both day and evening.

The sum of £20 8s. 3d. has been received for the general funds of the Institute as proceeds of a very successful musical and dramatic entertainment given by Nelson amateurs, and the committee is assured that the hearty thanks of all our members will be accorded to Miss H. Reeves and the ladies and gentlemen who kindly assisted to make the entertainment a success.

The committee desire to record their thanks to those who have kindly placed magazines and periodicals in the reading-rooms for the use of members, and to those who have generously presented books to the Institute.

The committee also again desires to express its appreciation at the efficient manner in which the duties of librarian have been performed by Miss Reeves, and the keen interest displayed by her on behalf of the Institute.

A noteworthy event of the past year has been the splendid gift made to the Institute by Mrs. A. S. Atkinson of a fine 5 in. refracting telescope constructed by the well-known firm of Messrs. Cooke and Sons, of York, and valued at about £300. This instrument is equatorially mounted, and has a driving-clock with attachments, besides clamps and slow motions

worked from the eye-piece of the telescope. It has a very full equipment of eye-pieces, magnifying from 30 to 800 diameters, a Cooke micrometer, stellar and solar diagonal, Dawes, Barlow, terrestrial, and transit eye-pieces. The instrument, which is to be known as the "Atkinson Telescope," in memory of the late Mr. A. S. Atkinson, has been set in position in a Berthon observatory, built by permission of the City Council in Alton Street, and will be available for use after the end of this week. It may be anticipated that with the facilities afforded by the possession of this instrument a number of our members will take up the study of astronomy.

The scientific branch of the Institute has met for microscope work, and proposes to hold periodical meetings during the coming winter for the discussion of scientific subjects.

Several gentlemen have also kindly volunteered to devote some of their leisure time in the near future to making a much-needed rearrangement of the exhibits in the Museum.

MANAWATU PHILOSOPHICAL SOCIETY.

A meeting of those interested in the formation of a Philosophical Society was called by circular and advertisement, and was held in the Borough Council Chambers on the 29th June, 1904. Mr. Kenneth Wilson, M.A., being voted to the chair, called on Mr. William Welch, the convener of the meeting, to explain the objects and aims of the New Zealand Institute and the formation of a Philosophical Society in Palmerston North.

Mr. Welch did this, and stated he had the names of nearly forty gentlemen who had signified their intention of joining.

It was resolved that the Philosophical Society be established, and that the names of those read out be the original members.

It was resolved that Messrs. Wilson, M.A., Welch, P. E. Baldwin, J. Vernon, M.A., and Dr. Martin be a committee to draft rules and laws, and to bring up a report at a future meeting.

It was resolved that Mr. William Welch act as Secretary and Treasurer *pro tem.*

The committee met on the 6th July, and drew up laws and rules for submission to the next meeting.

A meeting was called by circular, and met in the Borough Council Chambers to adopt rules, &c., and elect officers for the forthcoming year.

It was resolved that the name of the Society be "The Manawatu Philosophical Society"; and that the rules as submitted be adopted.

Election of Officers. — *President*—Kenneth Wilson, M.A.; *Vice-Presidents*—John Vernon, M.A., M. Cohen, and E. J. Armstrong; *Council*—Messrs. D. W. Low, J. C. Swallow, W. Collingwood, Dr. Martin, F. Foote, B.A., and H. W. Maclean; *Auditor*—R. N. Keeling; *Secretary and Treasurer*—William Welch.

FIRST MEETING: *17th August, 1904.*

The President, Mr. Kenneth Wilson, in the chair.

Mr. A. Hamilton, Director of the Colonial Museum, gave an address on the work of the New Zealand Institute, in which he traced the growth of the society from its earliest inception by Sir George Grey in 1851 up to the present time, when the whole of the societies and institutes in the colony were constituted one Institute by the Act of 1903.

SECOND MEETING: *15th September, 1904.*

The President, Mr. Kenneth Wilson, in the chair.

A paper by Mr. Skinner, of New Plymouth, was read by the Secretary on "Marsland Hill, New Plymouth," wherein was reviewed the stirring events centred round that historic spot during the early-settlement days. (*Transactions*, p. 211.)

A paper was also read on "Some Chinese Bronzes," by Mr. William Welch, and he exhibited several that were looted from the Forbidden City in Pekin at the time of the relief of the Legations in August, 1900, also a Buddha sent by the Dalai Lamma of Lhassa to the Emperor of China in the eighteenth century, in which was secreted several parchment scrolls. The translations made by the British Museum were also read. (*Transactions*, p. 208.)

A discussion followed each paper.

THIRD MEETING: *15th October, 1904.*

The President, Mr. Kenneth Wilson, in the chair.

A paper was read by Mr. G. Hirsch of a translation of an unpublished letter by Professor Hochstetter to Sir David Munro about fifty years ago on the geology of the Nelson district in relation to its gold-bearing properties.

Mr. Hirsch also made some copious remarks bearing on the subject.

A discussion followed, in which several members took part.

Mr. H. T. B. Drew was duly elected a member.

FOURTH MEETING: *17th November, 1904.*

The President, Mr. Kenneth Wilson, in the chair.

A paper was read by Mr. Duncan Sinclair on local geology, and after the reading he exhibited a large number of specimens collected between the Manawatu Gorge and the Oroua River.

Mr. Eliott also exhibited a good number of geological specimens from the thermal district of the North Island.

A very interesting discussion followed the reading of the paper.

FIFTH MEETING: *15th December, 1904.*

The President, Mr. Kenneth Wilson, in the chair.

A paper was read by Mr. M. A. Eliott on "Evolution," in which he traced the beginning of matter from the protyle up through the chemical changes of the inorganic and organic till man was reached.

This led to a very animated discussion, in which most of the members present took part.

APPENDIX

NEW ZEALAND INSTITUTE.

HONORARY MEMBERS.

1870.

FINSCH, OTTO, Ph.D., of Bremen, Leiden, Holland.

HOOKER, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., Royal Gardens, Kew.

1873.

GÜNTHER, A., M.D., M.A., Ph.D., F.R.S., Litchfield Road, Kew Gardens, Surrey.

1874.

NEWTON, ALFRED, F.R.S., Magdalen College, Cambridge, England.

1875.

SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S., Zoological Society, London.

1876.

BERGGREN, Dr. S., Lund, Sweden.

1877.

SHARP, Dr. D., University Museum, Cambridge.

1883.

Lord KELVIN, P.C., G.C.V.O., D.C.L., F.R.S., 18, Eaton Place, S.W.

ELLERY, ROBERT L. J., F.R.S., Observatory, Melbourne.

1885.

SHARP, RICHARD BOWDLER, M.A., F.L.S., Zoological Museum, Cambridge.

WALLACE, A. R., F.L.S., Broadstone, Wimborne, England.

1890.

NORDSTEDT, Professor OTTO, Ph.D., University of Lund, Sweden.

LIVERSIDGE, Professor A., M.A., F.R.S., Sydney.

1891.

GOODALE, Professor G. L., M.D., LL.D., Harvard University, Massachusetts, U.S.A.

1894.

DYER, Sir W. T. THISELTON, K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Royal Gardens, Kew.

CODRINGTON, Rev. R. H., D.D., Wadhurst Rectory, Sussex, England.

1895.

MITTEN, WILLIAM, F.L.S., care of Linnean Society, London.

1896.

LYDEKKER, RICHARD, B.A., F.R.S., British Museum, South Kensington.

LANGLEY, S. P., Smithsonian Institution, Washington, D.C.

1900.

AGARDH, Dr. J. G., University of Lund, Sweden.

AVEBURY, Lord, P.C., F.R.S., High Elms, Farnborough, Kent.

MASSEE, GEORGE, F.L.S., F.R.M.S.

1901.

EVE, H. W., M.A., 37, Gordon Square, London.

GOEBEL, Dr. CARL, University of Munich.

1902.

SARS, Professor G. O., University of Christiania, Norway.

1903.

KLOTZ, Professor OTTO J., 437, Albert Street, Ottawa, Canada.

1904.

RUTHERFORD, Professor E., McGill University, Canada.

DAVID, Professor T. EDGEWORTH, Sydney University, N.S.W.

ORDINARY MEMBERS.

WELLINGTON PHILOSOPHICAL SOCIETY.

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Adams, C. W.
Adams, Dr.
Allen, Frank
Aston, B. C.
Barker, G. Heriot, F.R. Met. Soc.
Barraud, W. F.
Barton, W.
Bates, Rev. D. C.
Beetham, George, London
Beetham, W. H.
Bell, E. D.
Bell, H. D.
Best, E., Hadfield
Blair, J. R.
Bothamley, A. T.
Brandon, A. de B.
Browne, M. H.
Buick, T. L., Palmerston N.
Buller, Sir W. L., K.C.M.G., D.Sc., F.R.S.
Caldwell, R.
Campbell, J. P.
Chalmers, A. B.
Chapman, Martin
Chapple, Dr. W. A.
Chudleigh, E. R.
Clarke, A. T.
Cockayne, A.
Cowan, J.
Cowper, D. A. S.
Dawson, B.
Denton, George
Dymock, E. R.
Easterfield, Prof., M.A., Ph.D.
Elliot, Major E. H. M., London
Ferguson, W., M.Inst.C.E.
Field, H. C., Wanganui
Fitzgerald, G., A.M.Inst.C.E.

Fletcher, Rev. H. J., Taupo
Fraser, Hon. F. H., M.L.C.
Freeman, H. J.
Freyberg, C.
Fyffe, Dr. W. K.
Gifford, A. C.
Gilruth, J. A.
Gordon, H. A., F.G.S.
Gray, W., Palmerston N.
Hadfield, E. F.
Hanify, H. P.
Harding, R. Coupland
Hastie, Miss J. A., London*
Hector, Sir James, K.C.M.G., M.D., F.R.S.
Hislop, Hon. T. W.
Hogben, G., M.A.
Holmes, R. L., F.R. Met. Soc., Fiji*
Holmes, R. T., Masterton
Hosking, Dr. A., Masterton
Hudson, G. V., F.E.S.
Hunter, T.
Hustwick, T. H.
Jenkins, Digby A., Otaki
Johnson, G. Randall*
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Keys, B.
King, T.
Kingsley, R. I., Nelson
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Kirk, T. W., F.L.S.
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Lewis, J. H., Otago
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Litchfield, A. J., Blenheim
Lomax, H. A., Wanganui
Longton, Mrs. C. V., Christchurch
Mason, G. M.
Mason, Mrs. Kate
Matheson, D.
Maxwell, J. P., M.Inst.C.E.
Mestayer, R. L., M.Inst.C.E.
Moore, G.
Moorehouse, W. H. S.
Morison, C. B.
Murdoch, R., Wanganui
McDougall, A.
McKay, Alexander, F.G.S.
Mackenzie, F. Wallace, M.B.
Maclaurin, Prof. R. C., M.A.
McLeod, H. N.
McWilliam, Rev. J., Otaki
Newman, Alfred K., M.B., M.R.C.P.
Orr, Robert
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Petherick, E. W.
Phillips, Coleman, Carterton
Pierard, C. H.
Pollen, Hugh
Ponsonby, Mrs. Amy
Powles, C. P.
Poynton, J. W.
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Reid, W. S.
Richardson, C. T.
Robinson, W. F., Masterton
Roy, R. B., New Plymouth*
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Rutherfurd, W. G., Timaru
Skerman, Dr. Sidney, Marton
Smith, Charles, Wanganui
Stewart, J. T., Wanganui
Stowell, H. M.
Tait, P. W.
Travers, H. H.
Tregear, E.
Turnbull, A. H.
Turnbull, R. T.
Turnbull, Thomas
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Wallis, Rt. Rev. Dr. Frederic, Bishop of Wellington
Welch, W., Palmerston N.
Wilton, G. W.
Woodhouse, Alfred James, London

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Brett, H., Auckland
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Brown, Prof. F. D., Auckland
Buchanan, J., Auckland
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Burton, Colonel, Lake Takapuna*
Busck, A., Auckland
Cameron, R., "
Campbell, H., "
Campbell, Sir J. L., M.D., Auckland*
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Carr, R. A., "
Casey, M., "
Cheal, P. E., "
Cheeseman, T. F., F.L.S., Auckland
Cheeseman, H. H., M.R.C.S., Coromandel
Ching, T., Remuera
Clark, H. C., Auckland
Clark, M. A., "
Clarke, E., "
Cochrane, W. S., "
Combes, F. H., "
Cooper, C., "
Cooper, Mr. Justice, Wellington.
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Craig, J. J., "
Crosher, W., "
Cummings, H., "
Dannefærd, S., "
Darby, P., "
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Frengley, J. P., M.D., Auckland
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Girdler, Dr., Auckland
Goldie, D., "
Gordon, H. A., "
Gorrie, W., "
Gray, S., "
Haines, C. H., M.D., F.R.G.S., London
Haines, H., F.R.C.S., Auckland
Hamer, J. H., C. E., Auckland
Hardie, J., Auckland
Haszard, H. D. M., Thames
Henry, J., Auckland
Henry, W., "
Henton, J. S., "
Herbert, T., Parnell
Howden, J., Auckland
Howell, J. H., B.Sc., Auckland
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Jones, H. W., Papakura
Kenderdine, J., Auckland
Kidd, A., M.H.R., Auckland

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Lennox, W. G., Sydney*
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Mueller, G., "
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Partridge, H. E., "
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Bealey, S.
Beckett, T. W. Naylor
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Bishop, R. C.
Blunt, Prof. T. G. R., M.A.
Booth, G. T.
Bowen, Hon. C. C., M.A., F.R.G.S.
Bridges, G. G.
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Burley, W. E.
Carlisle, W. J.
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Collins, J. J.
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Cuthbert, E., M.Inst.C.E.
Denham, H. G.
Denniston, Mr. Justice
Drummond, J.
Enys, J. D.
Evans, Prof. W. P., M.A., Ph.D.
Farr, Dr. Coleridge, Assoc.M. Inst.C.E.
Finch, Dr.
Fisher, F. M. B.
Flower, A. E., M.A., B.Sc.
Fodor, Miss
Freeman, Miss
Frengley, Dr. J. P.
Gibson, Dr. F.
Gray, Alex., B.A.
Gray, George, F.C.S.
Grimes, Right Rev. Bishop
Hall, Sir John, K.C.M.G.
Hardie, C. D.
Harling, C.
Hight, J., M.A.
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Kitchingman, Miss E., M.A.
Laing, R. M., M.A., B.Sc.
Lee, H. M.
Lowrie, Prof. W., M.A., B.Sc.
Marriner, G. R.
Mayne, J. B., M.A.
Mollett, T. A.*
Moreland, Rev. C. H., M.A.
Moorehouse, Dr. B. M.
Moyes, W. H., B.A.
Murray-Aynsley, H. P.
Nairne, R.
Olliver, Miss F. M., M.A., B.Sc.
Page, S.
Pairman, Dr. W. J.
Palmer, J.
Pemberton, O. B.
Purnell, C. W.
Reece, W.
Rhodes, R. Heaton, M.A.
Roper, E. W.
Sandstein, E. M.
Scott, Henry
Scott, Prof. R. J., M.Inst. Mec.E.
Seager, J. H.

Sims, A.
Slomam, C. J.
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Speight, R., M.A., B.Sc.
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Stevenson, Dr. J.
Stone, F.
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Terry, F.
Thomas, Dr. W.
Trolove, P.
Wallick, M. G.
Waymouth, F.
Williams, C. J., M.Inst.C.E.
Wright, A.

Associates.

Spieler, J.
Schneider, P.

OTAGO INSTITUTE.

[* Life members.]

Allan, Dr. W.
Allen, J., M.H.R., M.A.
Armstrong, F.
Barnett, L. E., M.B., F.R.C.S.
Barningham, J.
Batchelor, F. C., M.D., M.R.C.S.
Bathgate, Alexander*
Bell, A. D.
Benham, Professor, D.Sc., M.A., F.Z.S.
Bews, D. J.
Black, A. D.*
Black, Professor, D.Sc.
Blair, John
Bowman, J.
Brent, Daniel, M.A.*
Brown, William
Buchanan, N. L.*
Burnside, J. A.
Campbell, Robert
Carew, W. S.
Chamberlain, C. W.
Chapman, C. R.
Chapman, Mr. Justice
Chisholm, Robert
Collier, E. E.
Collins, F. J.
Colquhoun, D., M.D., M.R.C.S.
Don, Dr. J. R., D.Sc., M.A.
Duncan, Peter
Fels, Willi
Fenwick, George
Ferguson, H. Lindo, M.D., F.R.C.S.I.
Fitchett, Dr. Frank
Fulton, R., M.B., C.M.
Fulton, S. W.*
Gibbons, Professor, M.A.
Gilkinson, Robert
Gilkison, Robert
Goyen, P.
Hardy, H. F.
Hay, Dr. F.
Herbert, E.
Hocken, Dr. T. M., M.R.C.S., F.L.S.
Hosking, J. H.
Howes, G. W., F.E.S.
Jackson, Howard
Joachim, George*
Kempthorne, T. W.
King, Dr. F. Truby
Lamb, Thompson
Langmuir, John
Lusk, T. W.
Marchant, Miss M. E. A., M.A.
Marshall, Dr. P., D.Sc., M.A., F.G.S.
Matthews, J. H.
McKerrow, James, F.R.A.S.
McKnight, Miss S., M.A., B.Sc.
McNicol, D. A.
McPhee, J. H.

Meggett, A.
Melland, E.*
Michie, Alexander
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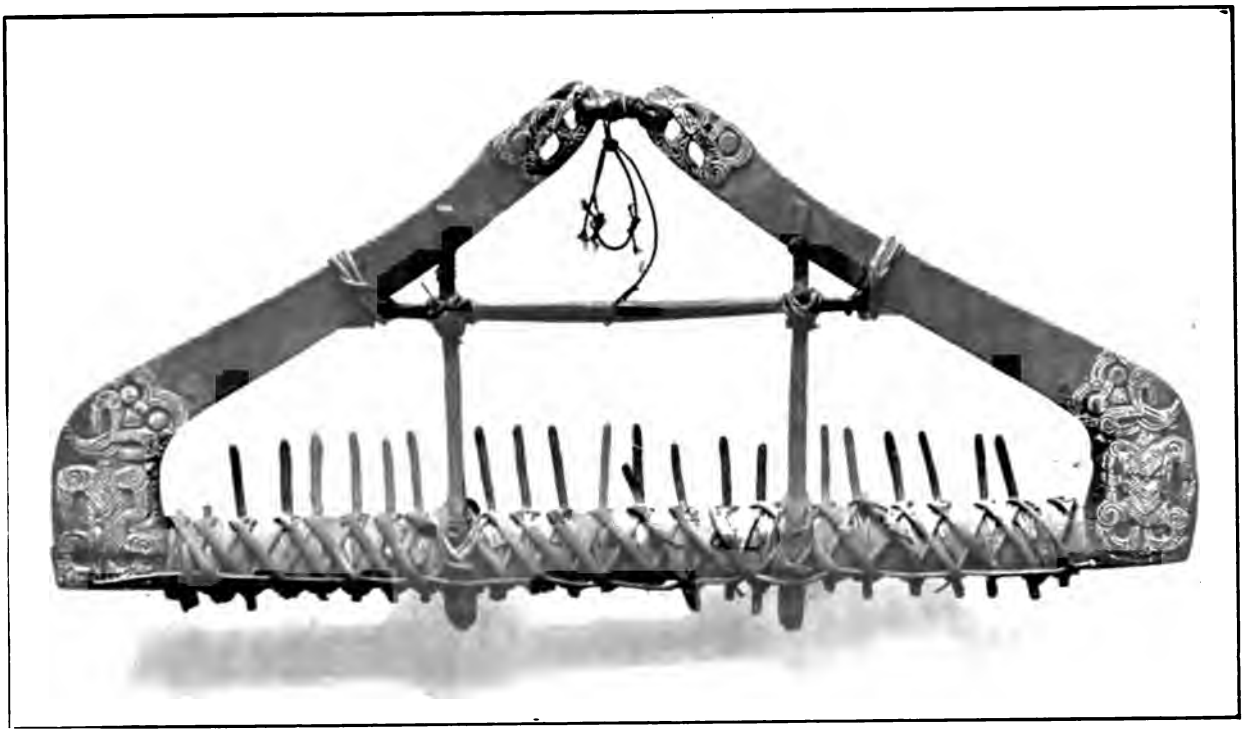

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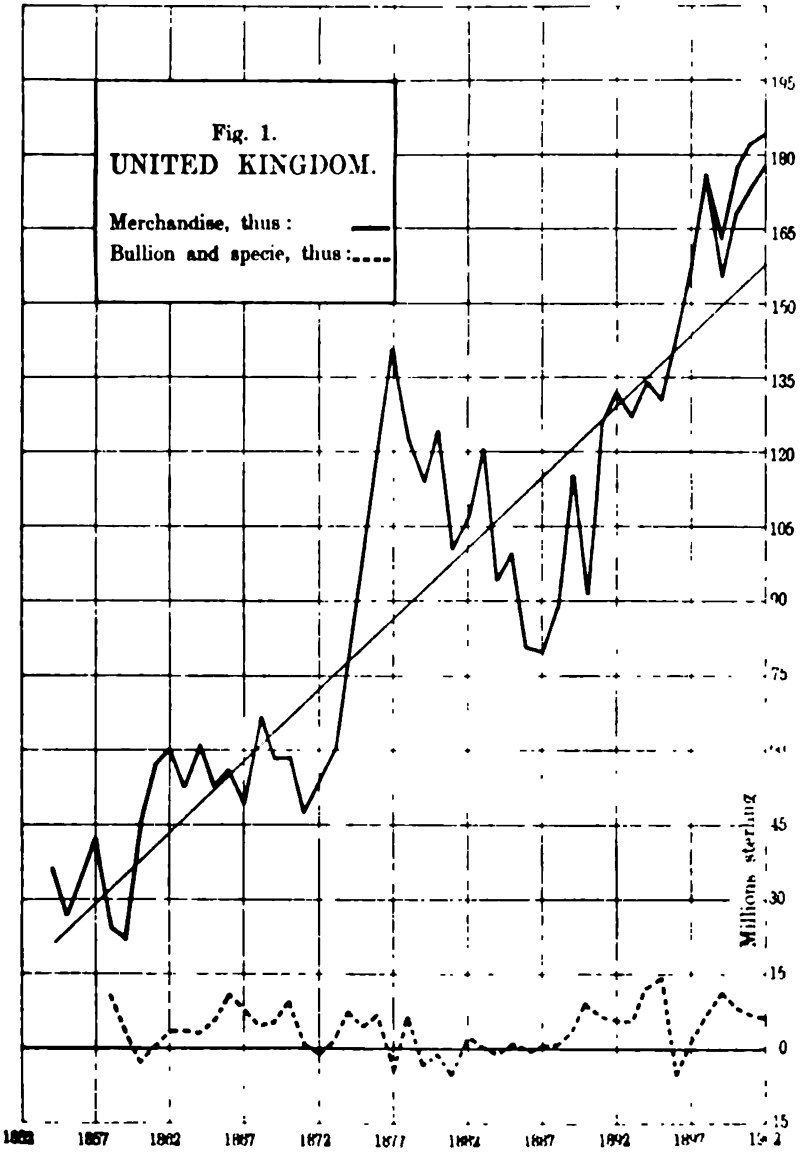

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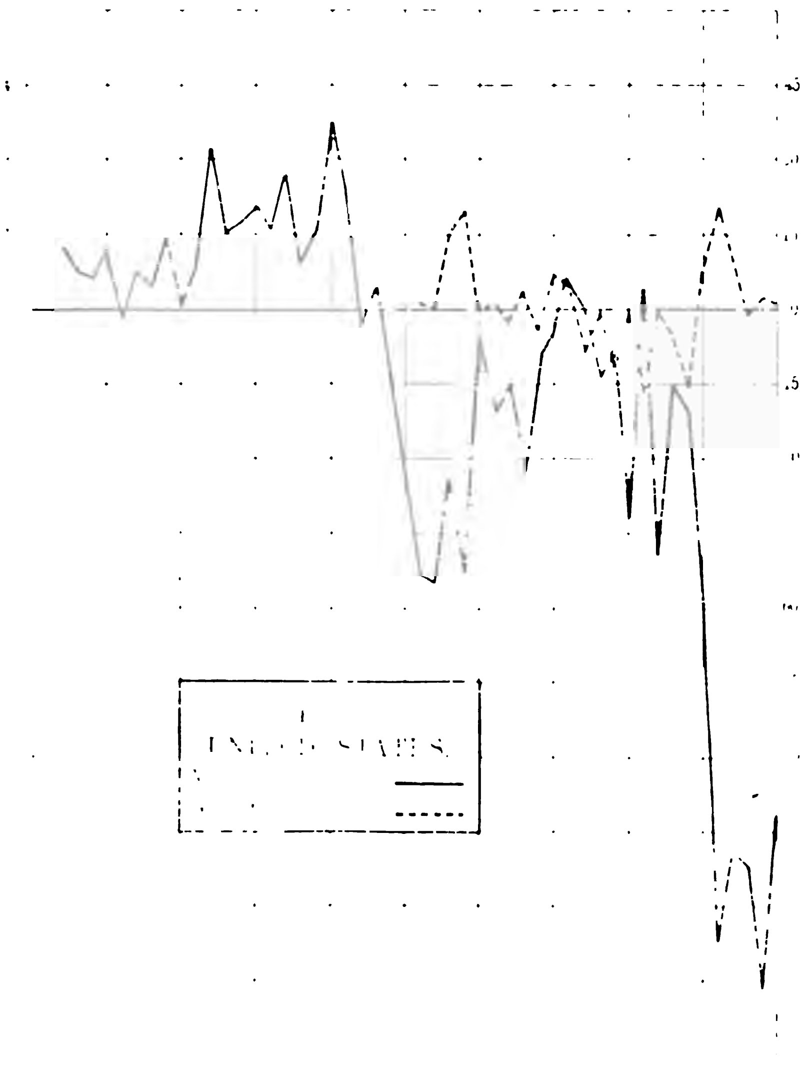

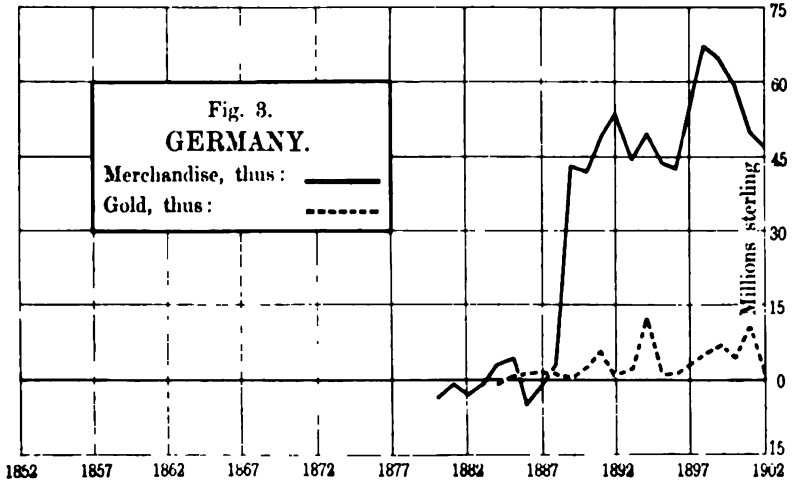

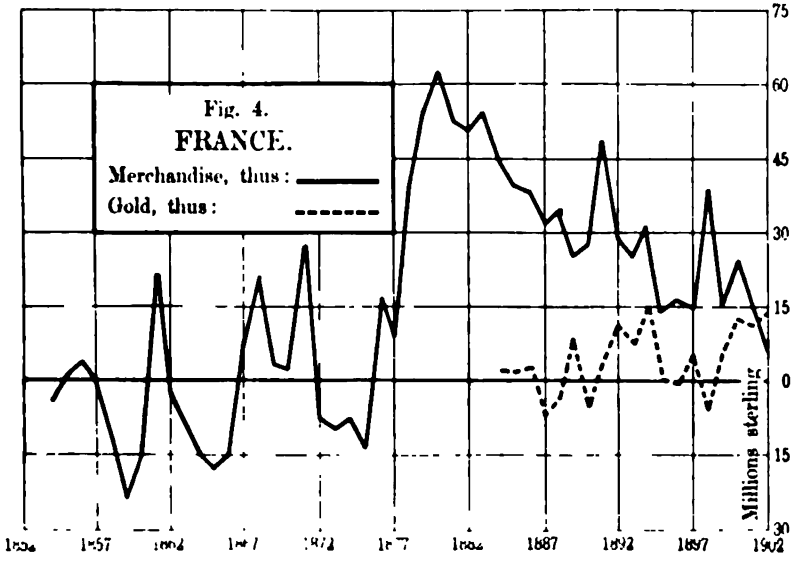

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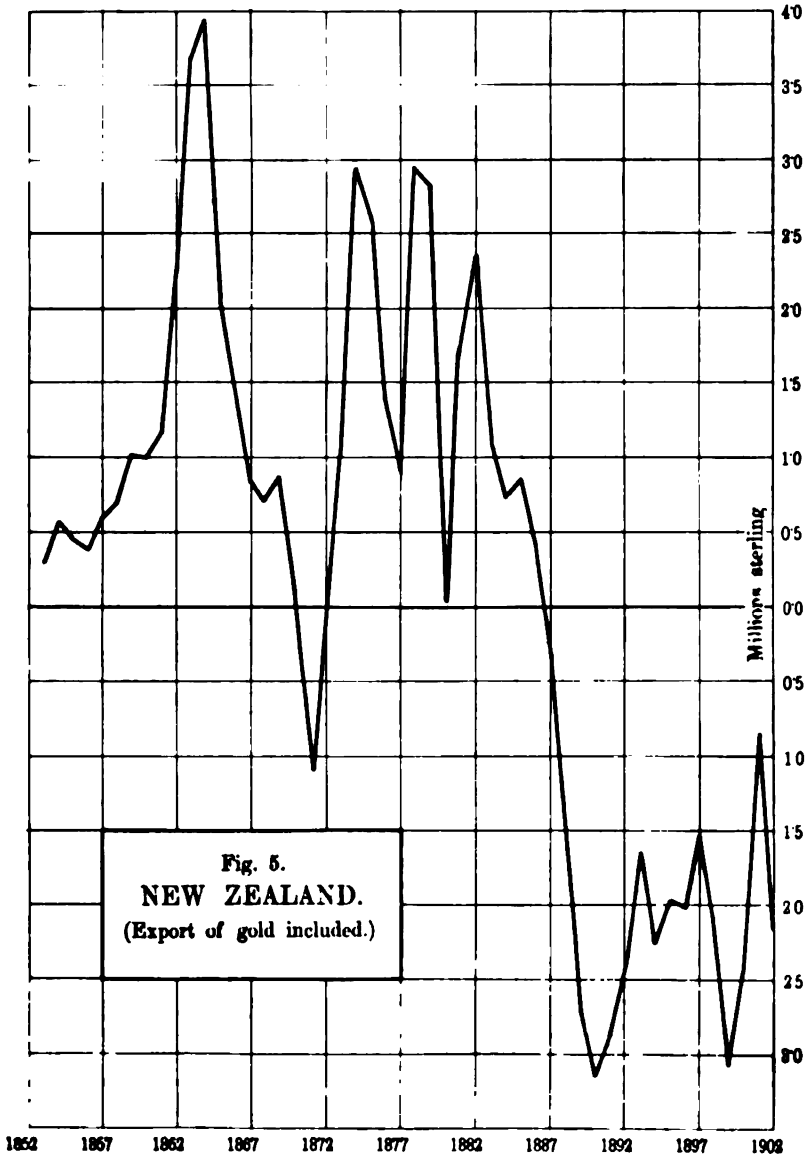

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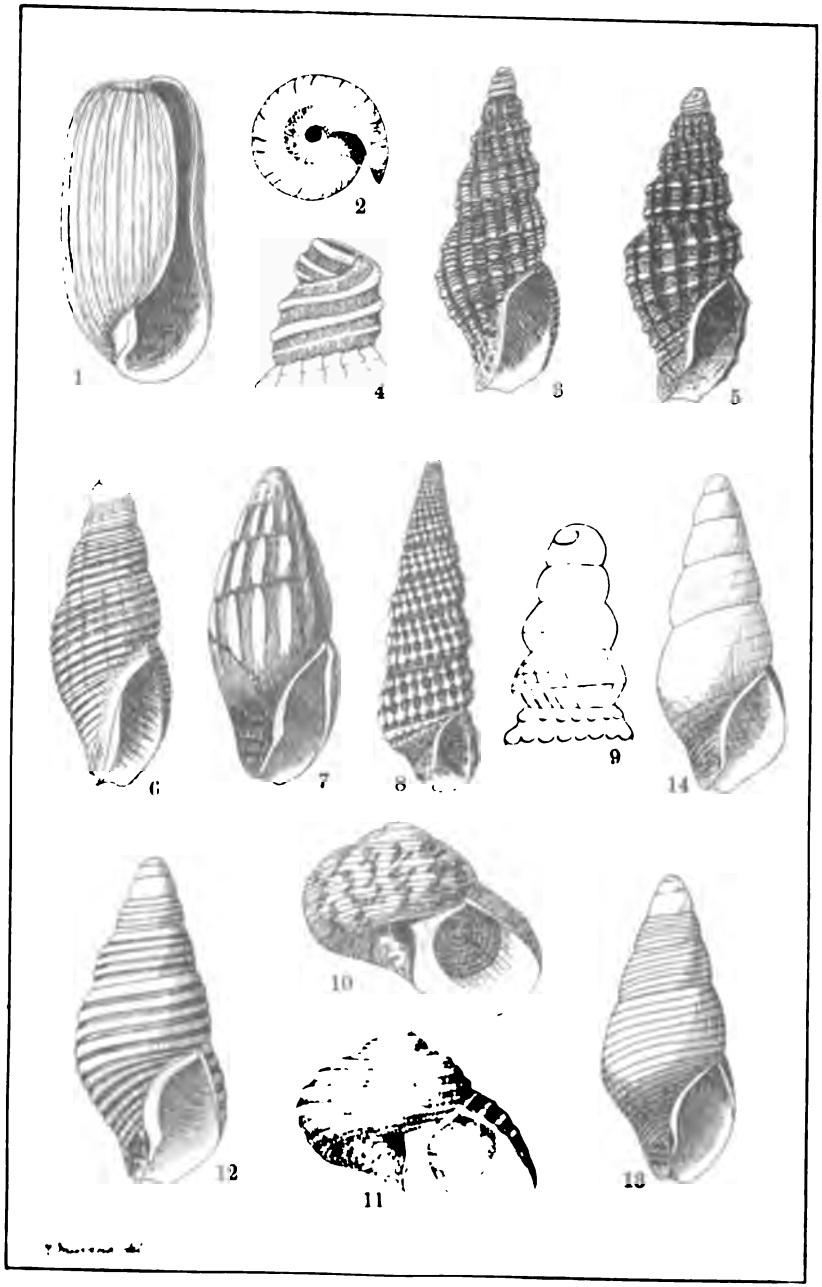

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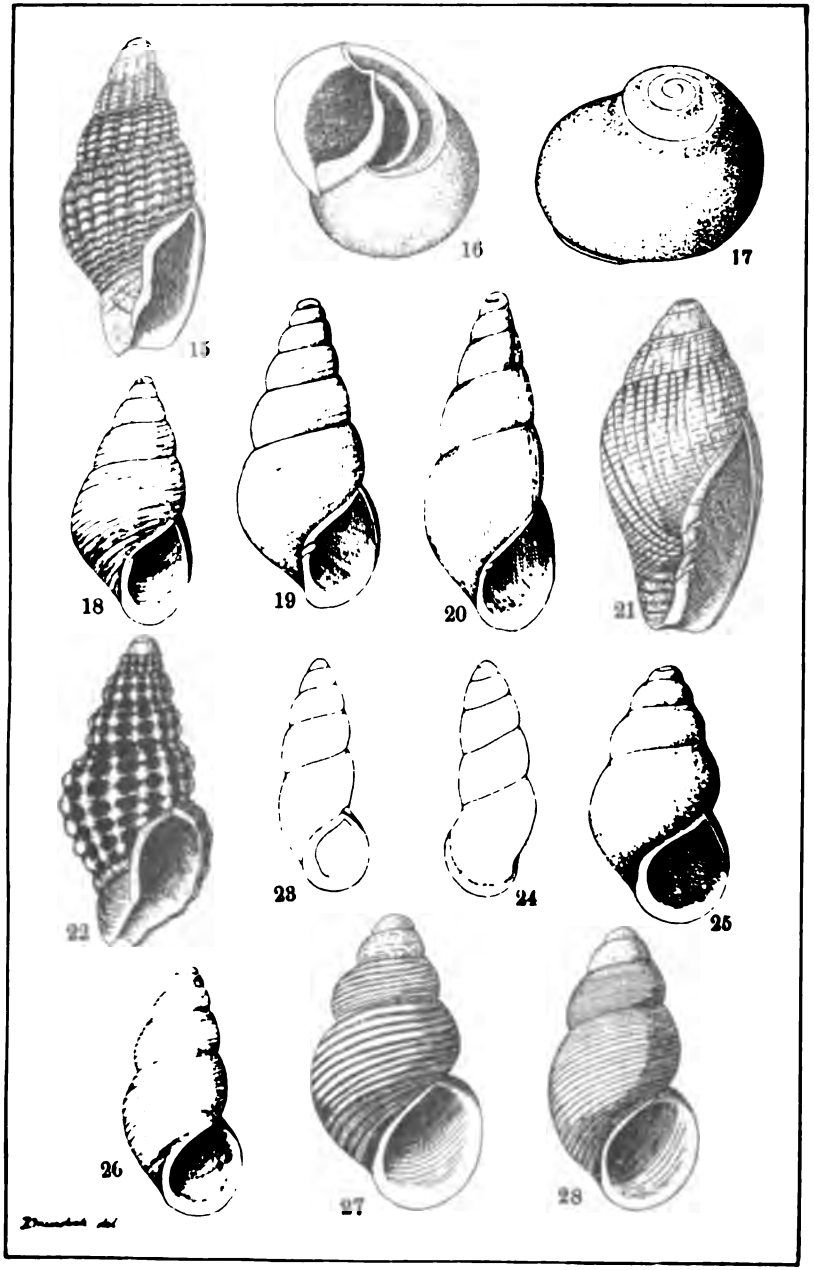

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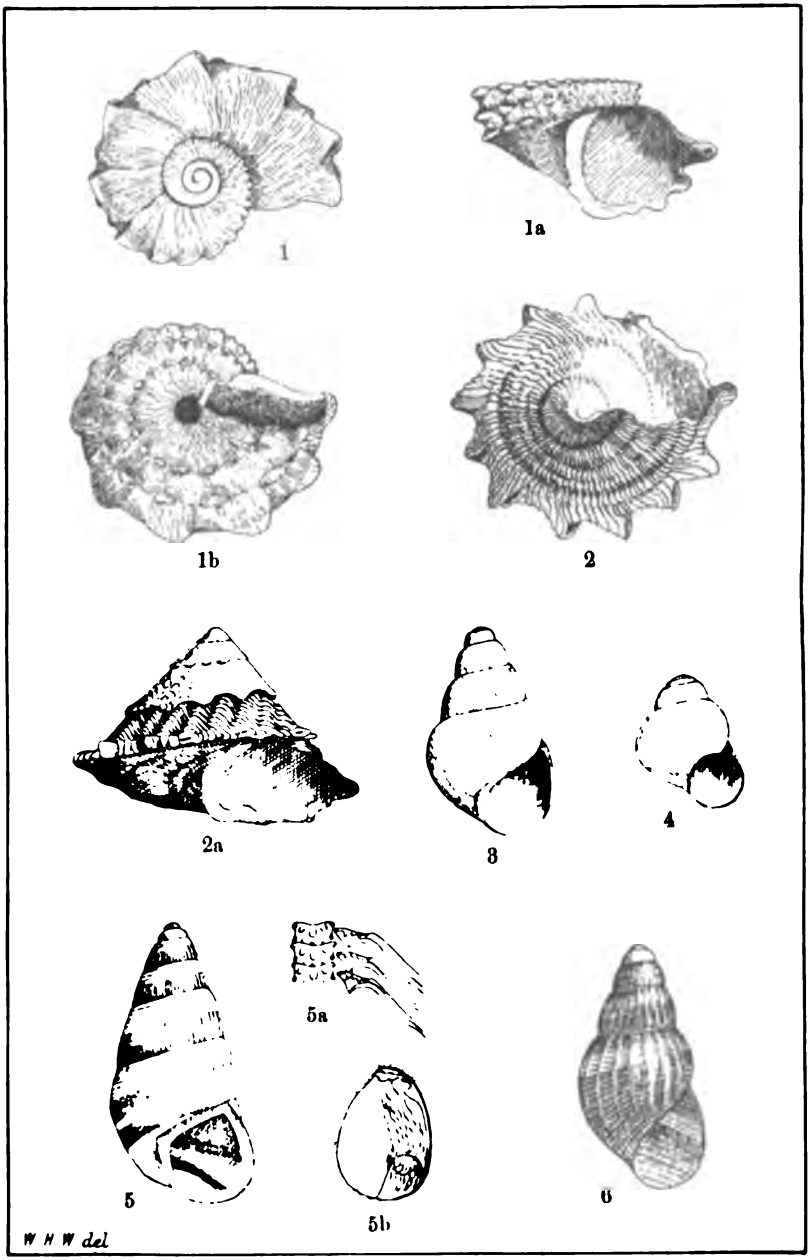

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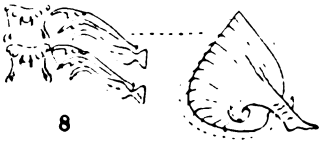

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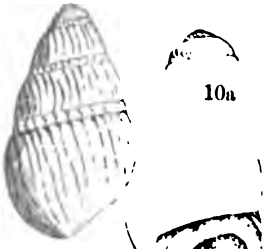

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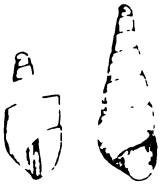

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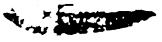

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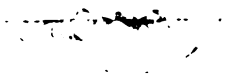

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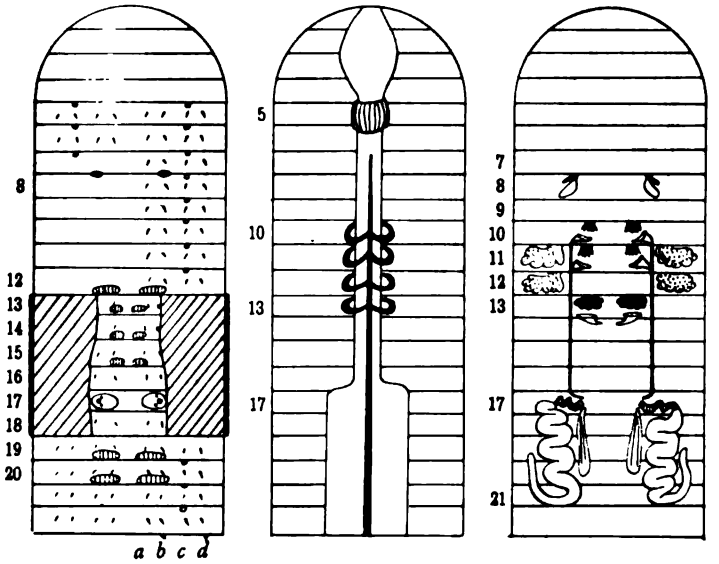
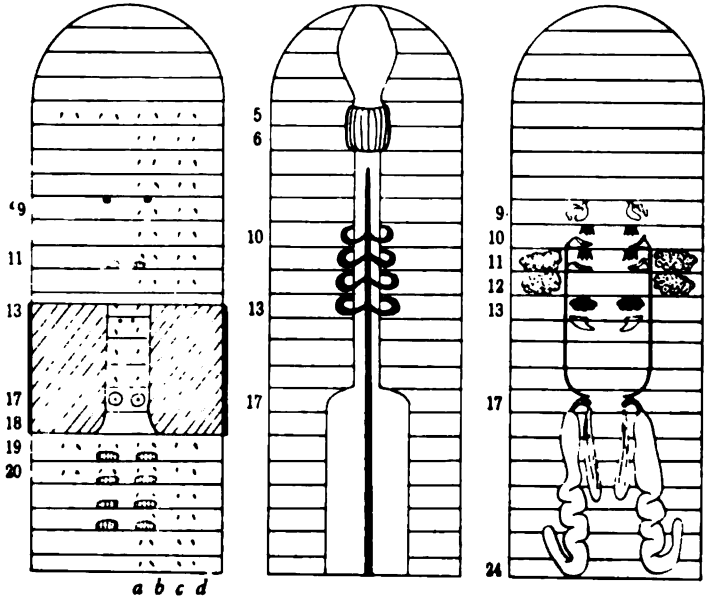
W. & W. del.

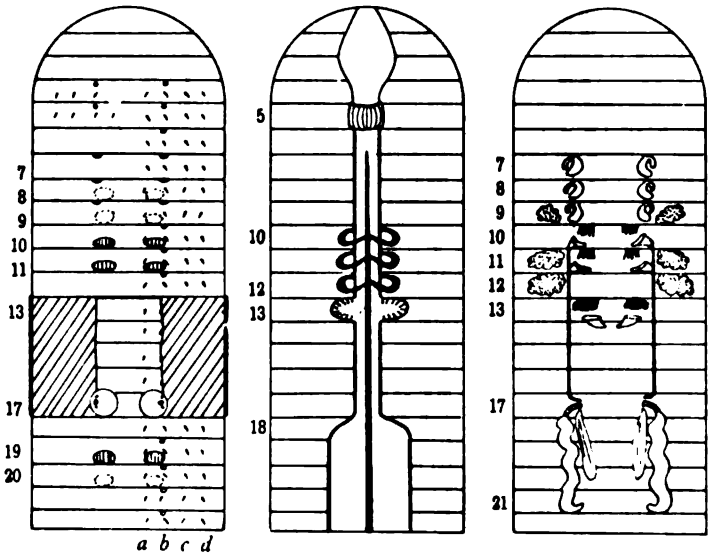
NEW ZEALAND MARINE SHELLS.—Webster.



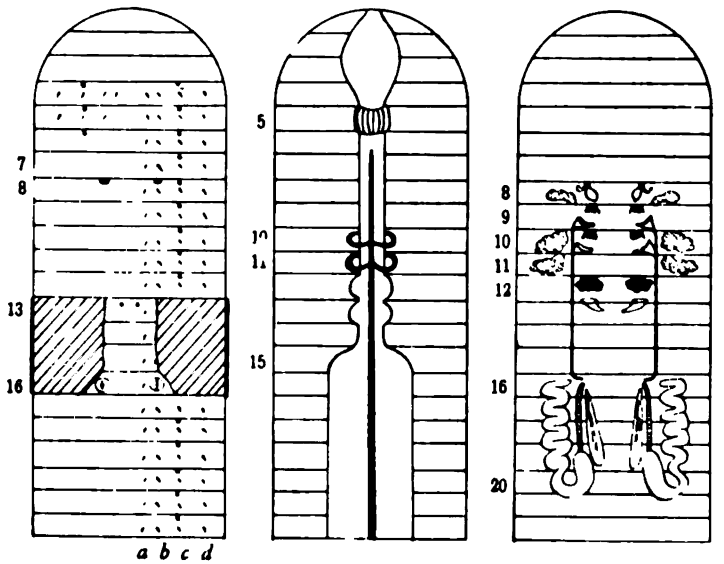
Rhododrilus edulis.



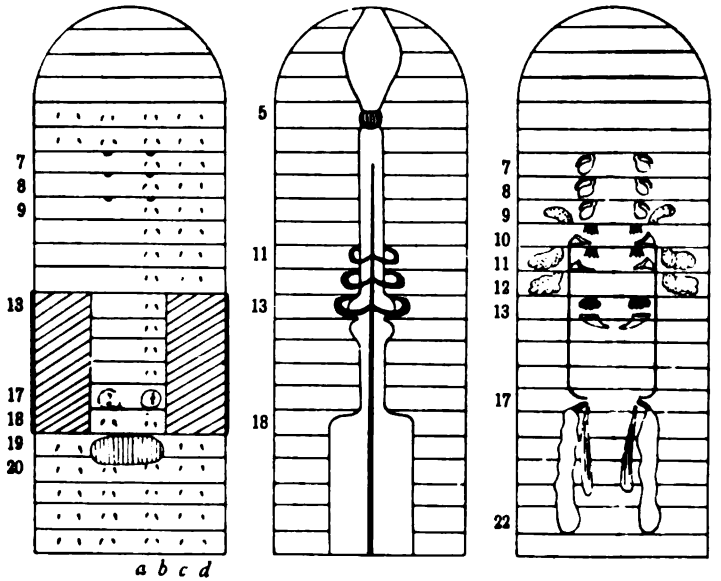
Rhododrilus besti.



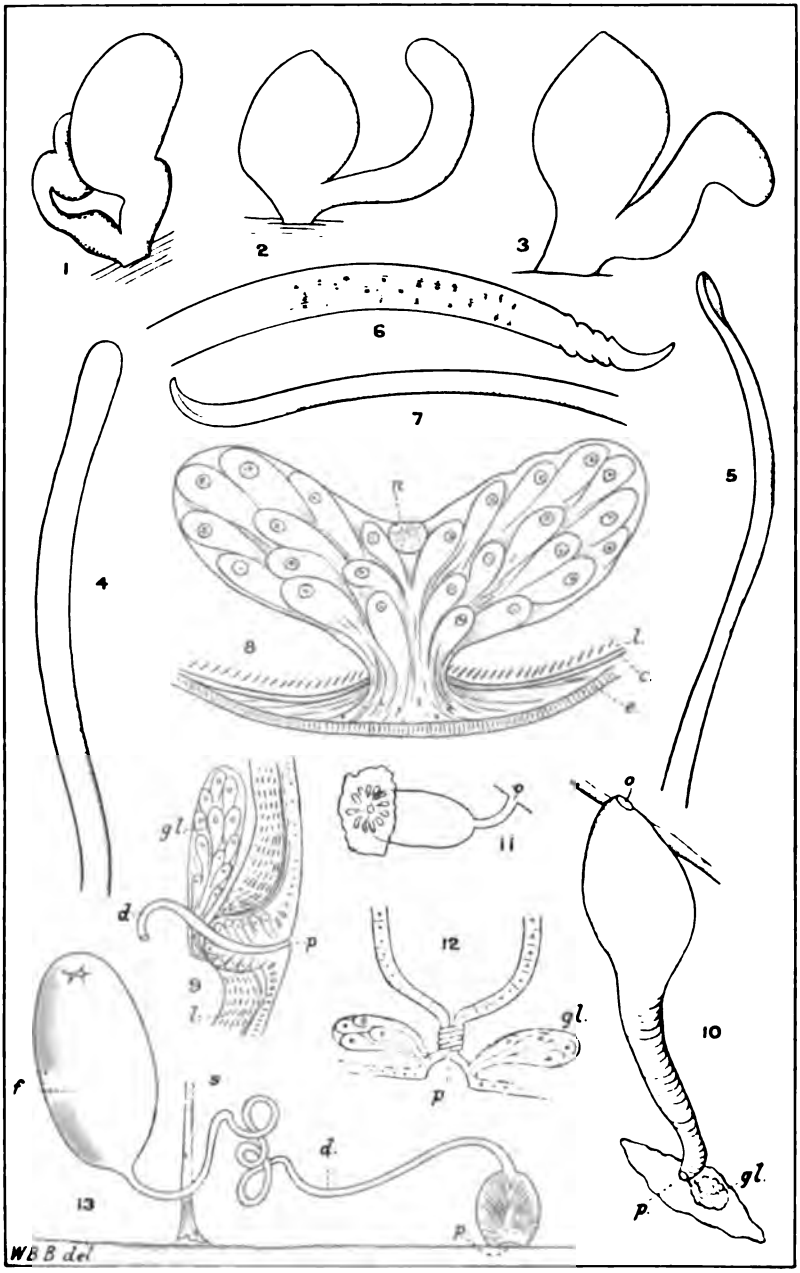
Rhododrilus cockayni.



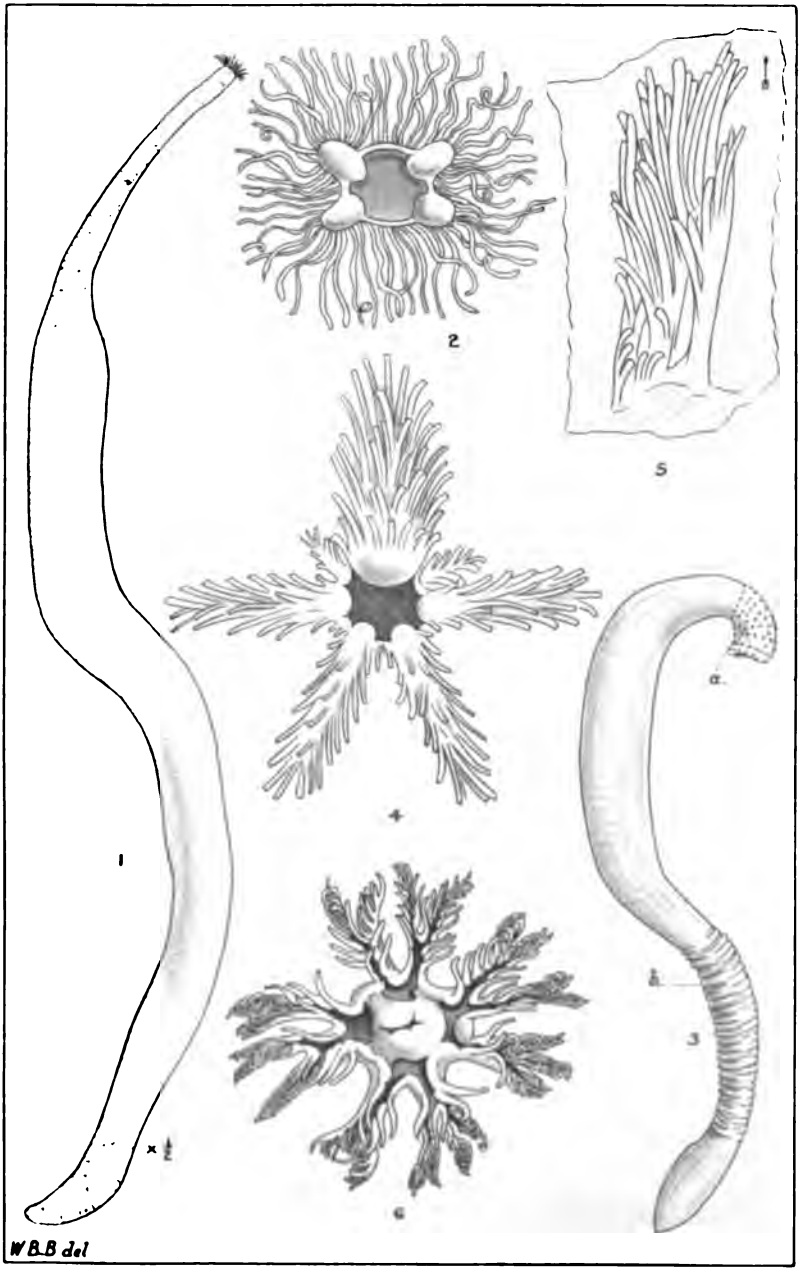
Rhododrilus leptomerus.



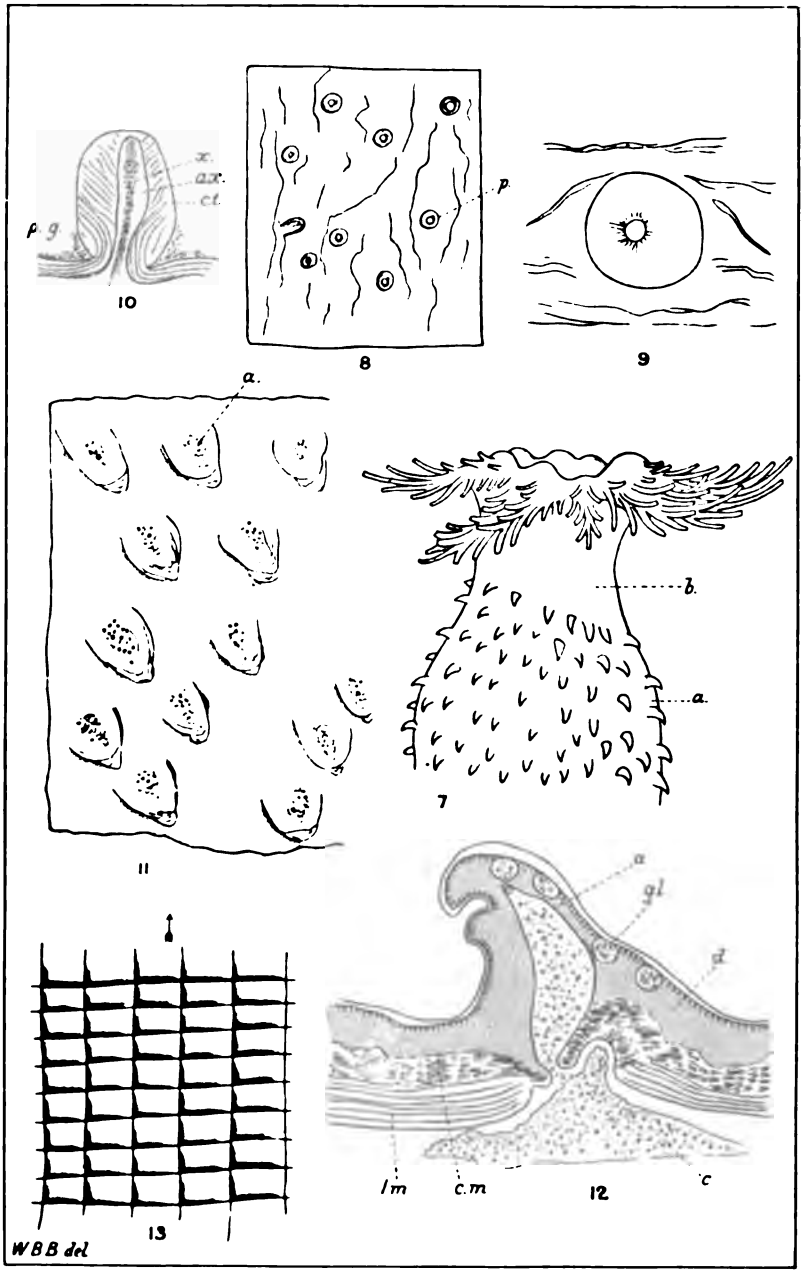
Rhododrilus kermadecensis.



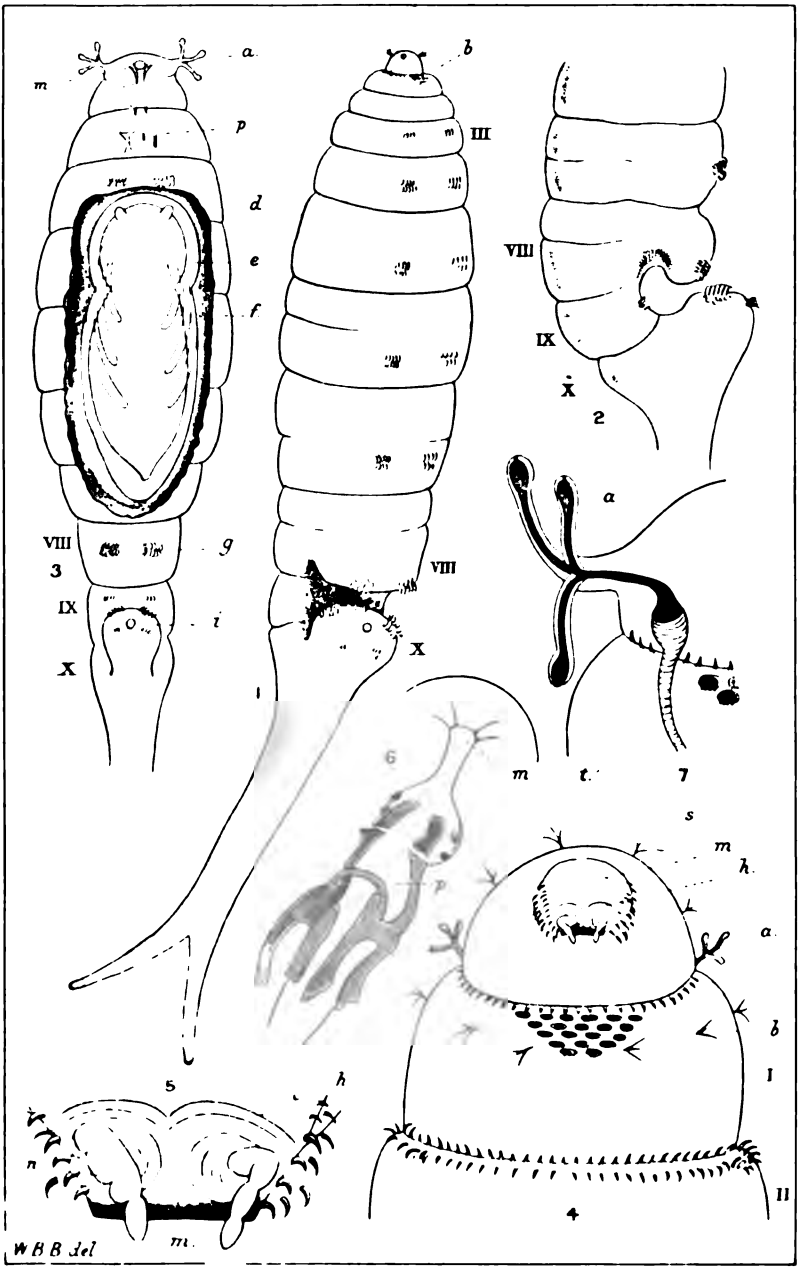
EARTHWORMS.—Benham.



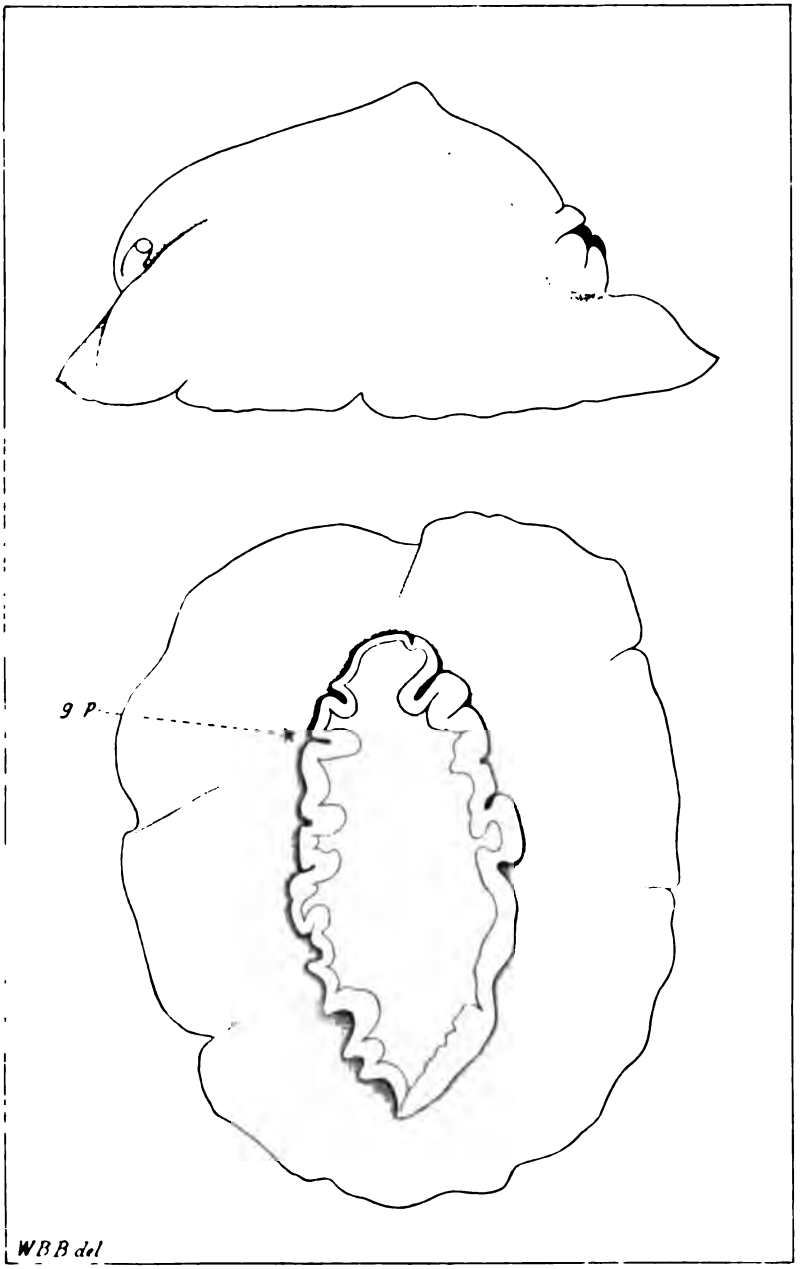
N.Z. SIPUNCULIDS.—Benham.



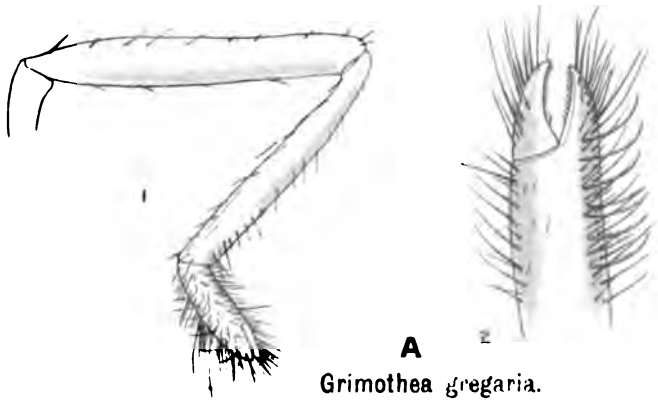
N.Z. SIPUNCULIDS.—Benham.



EPHYDRA.—Benham.

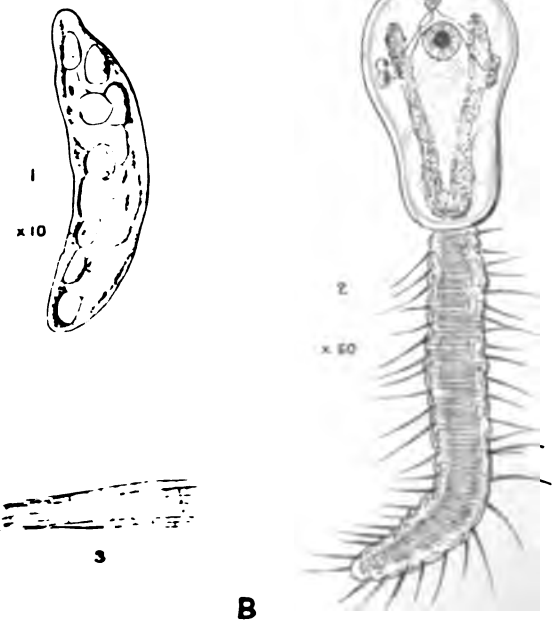


ATAGENA CARINATA.—Benham.



A

Grimothea gregaria.

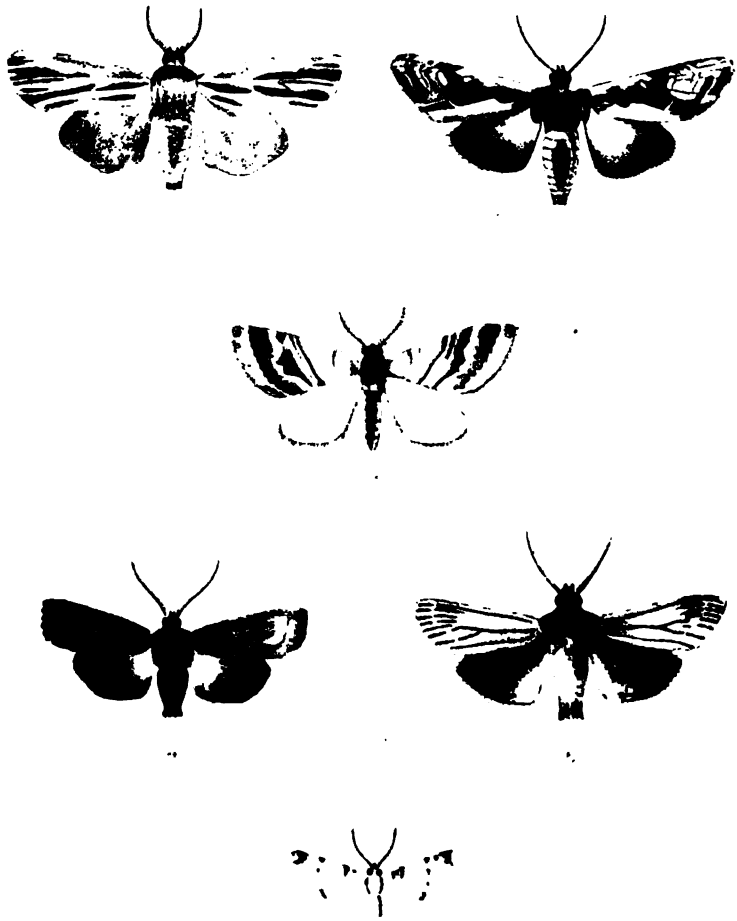


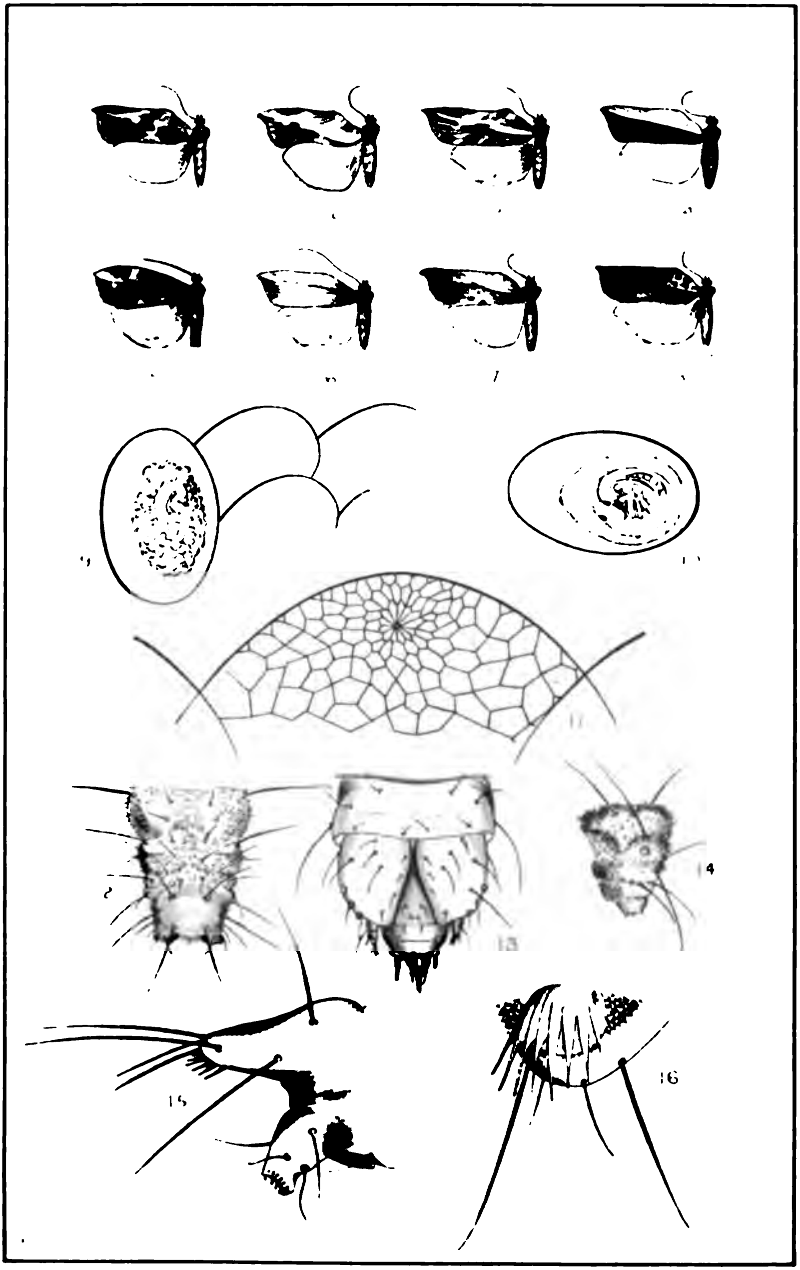
B

Cercaria pectinata.

Jas. Chilton del

GRIMOTHEA AND CERCARIA.—Chilton.





EPALXIPHORA AXENANA (Q...)

2

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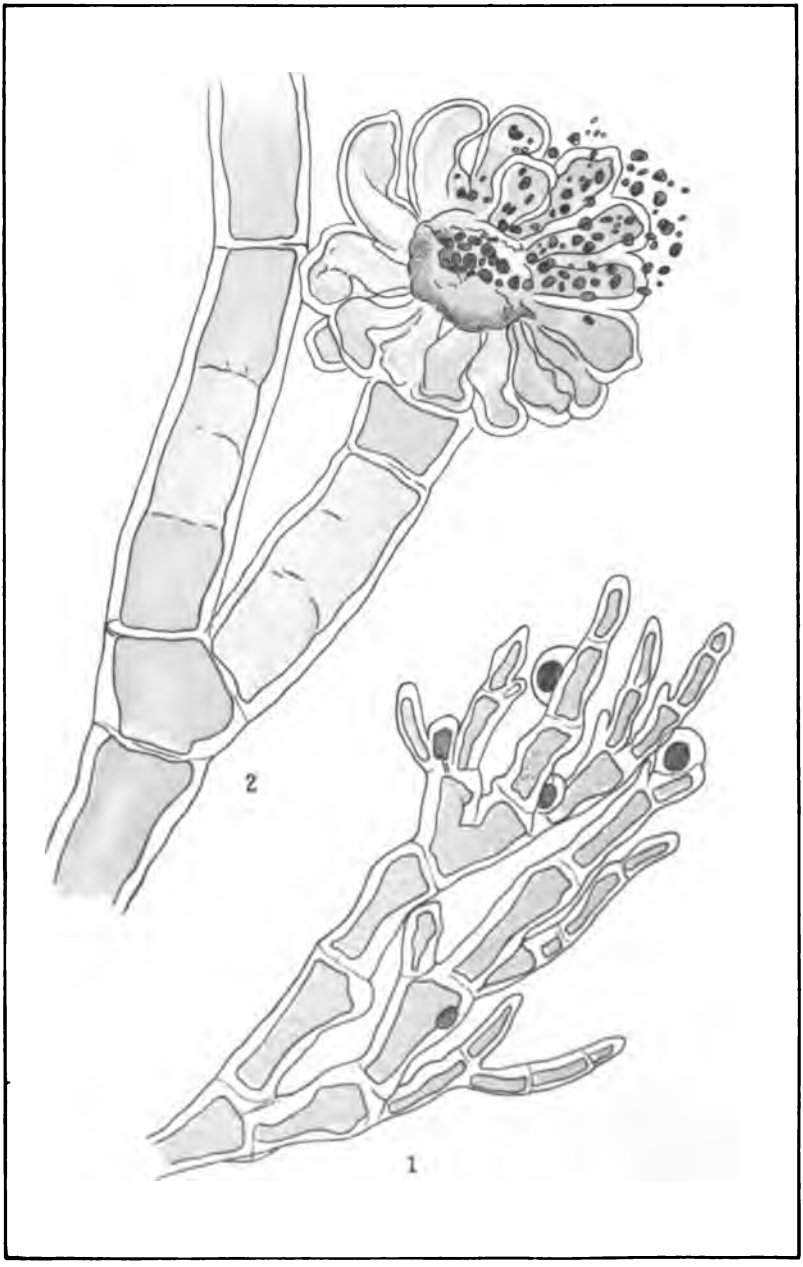
5

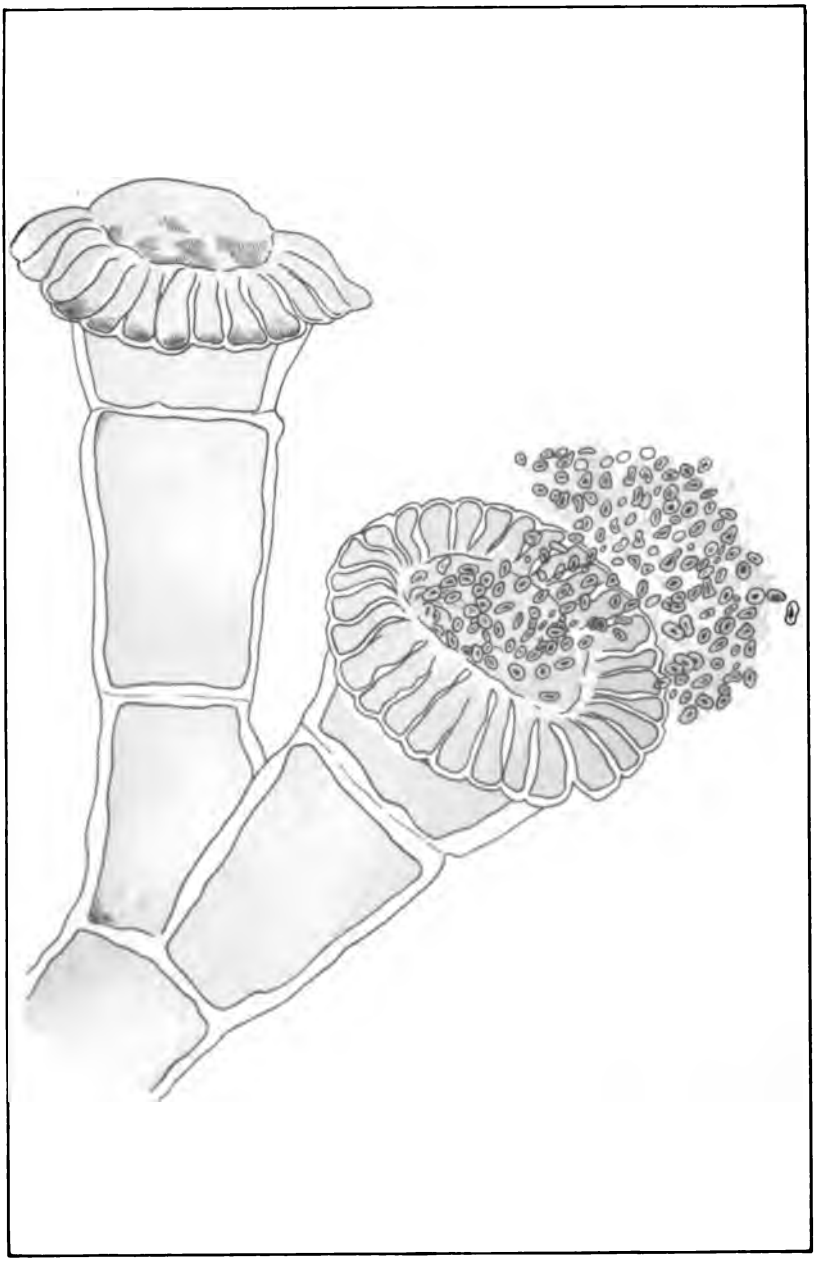
NEW MACRO-LEPIDOPTERA. Hudson.

VEGETATION, OPEN BAY ISLANDS.—Cockayne.

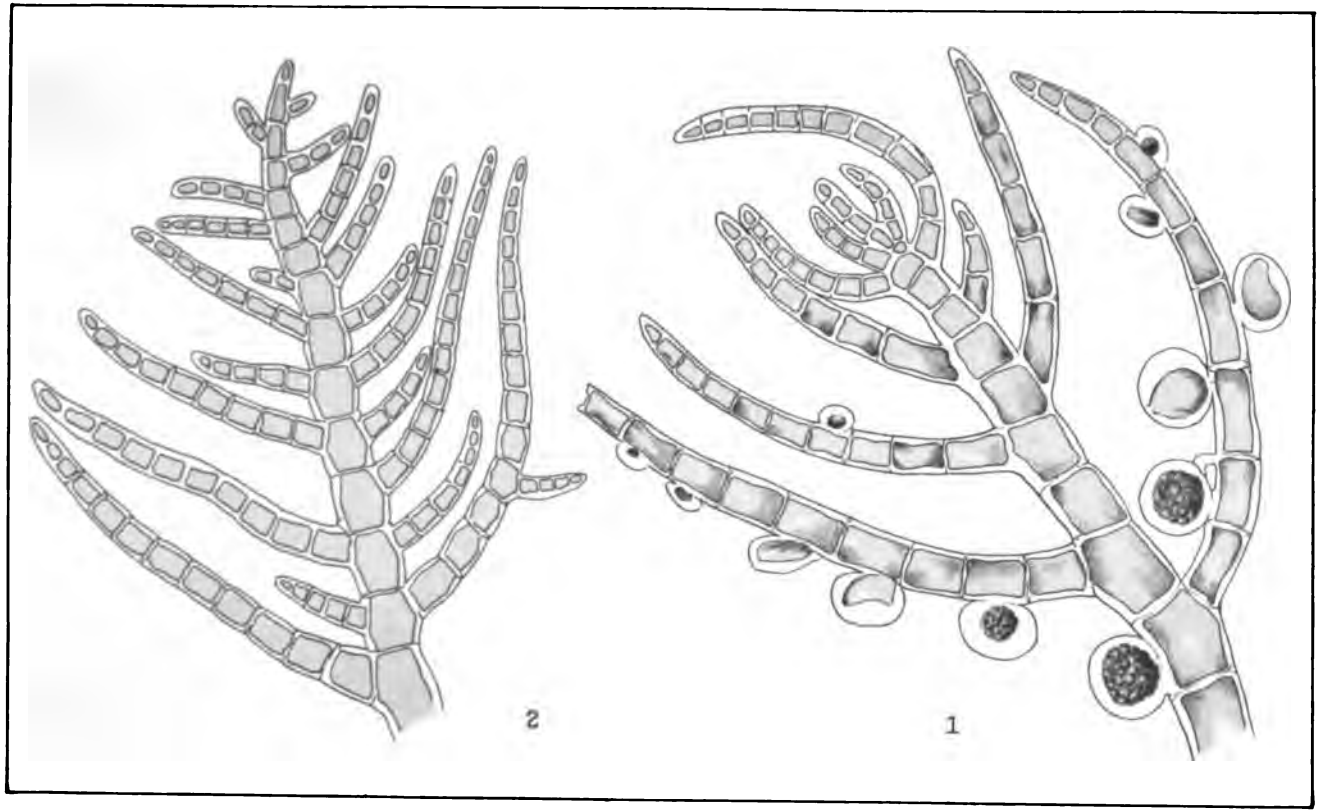
N.Z. CERAMIACEAE.—Laing.



N.Z. CERAMIACEAE.—Laing.



N.Z. CERAMIACEAE.—Laing.



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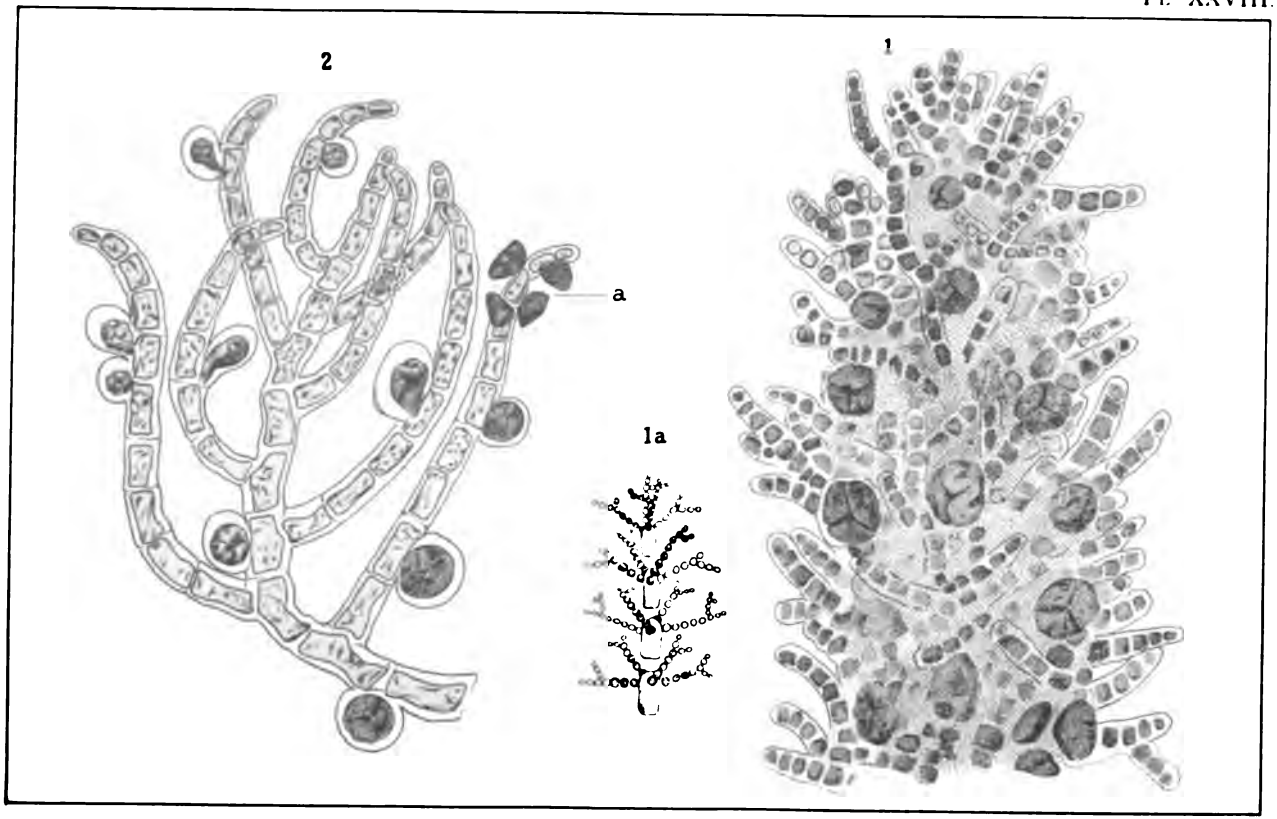

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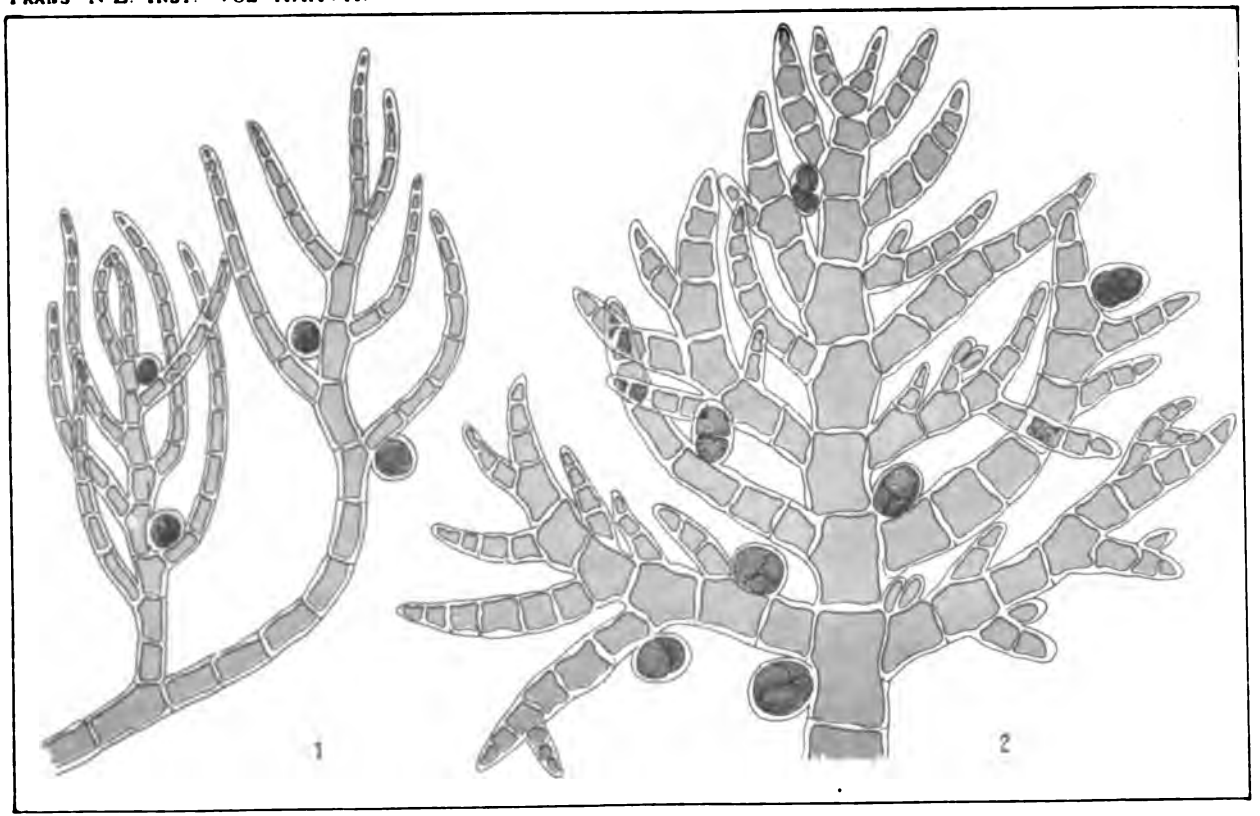

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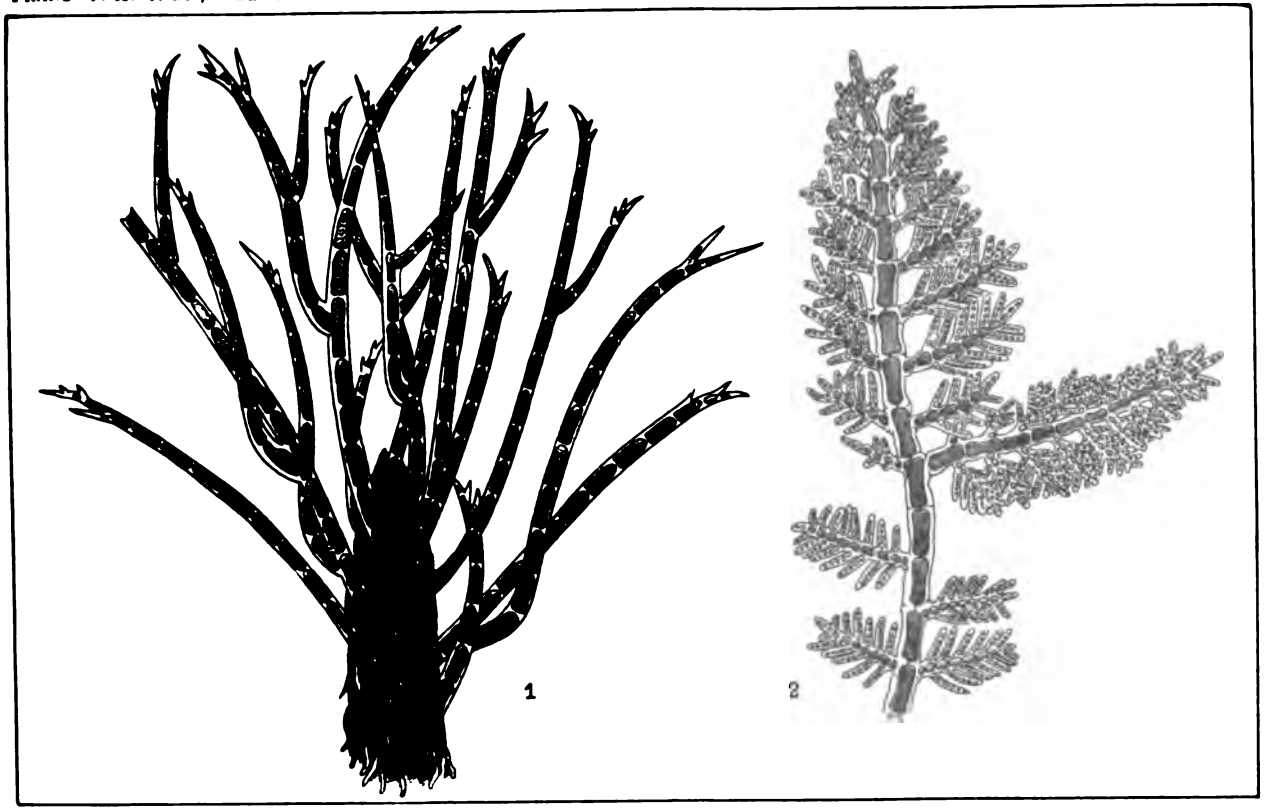

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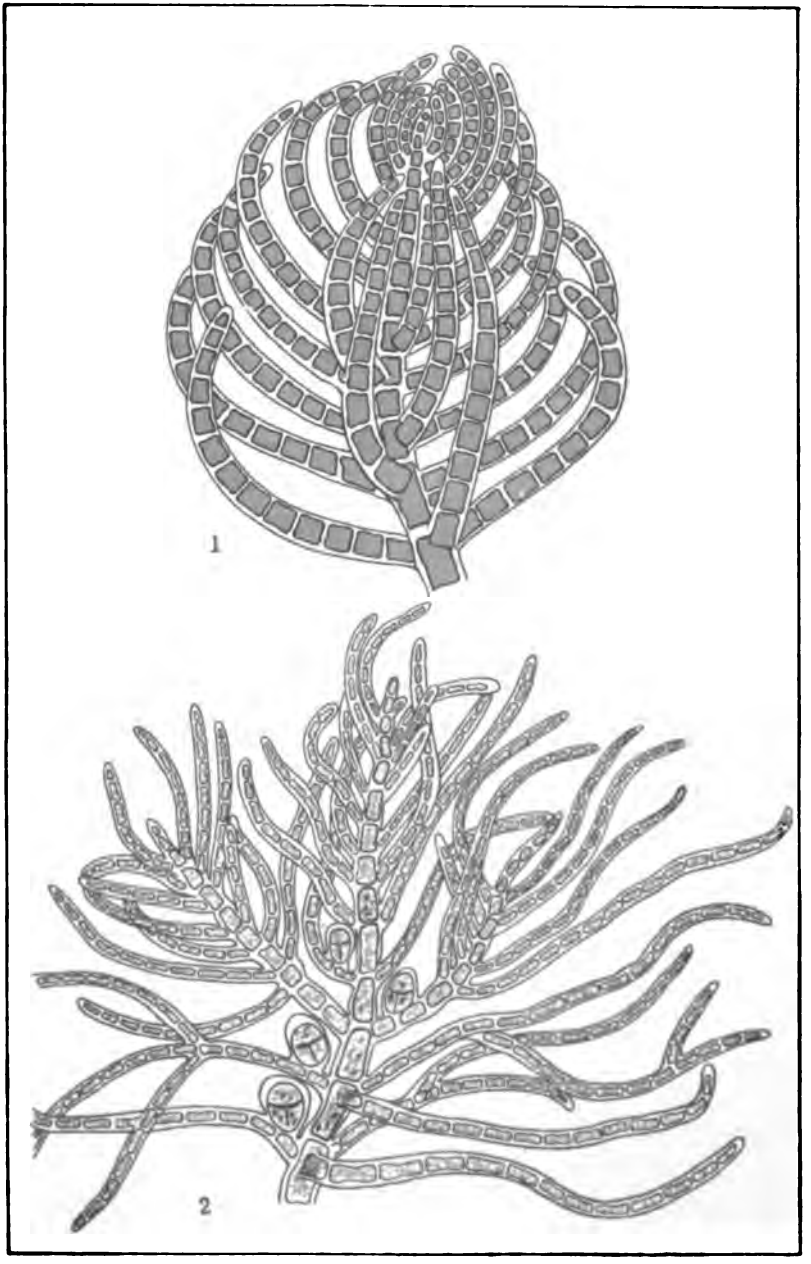

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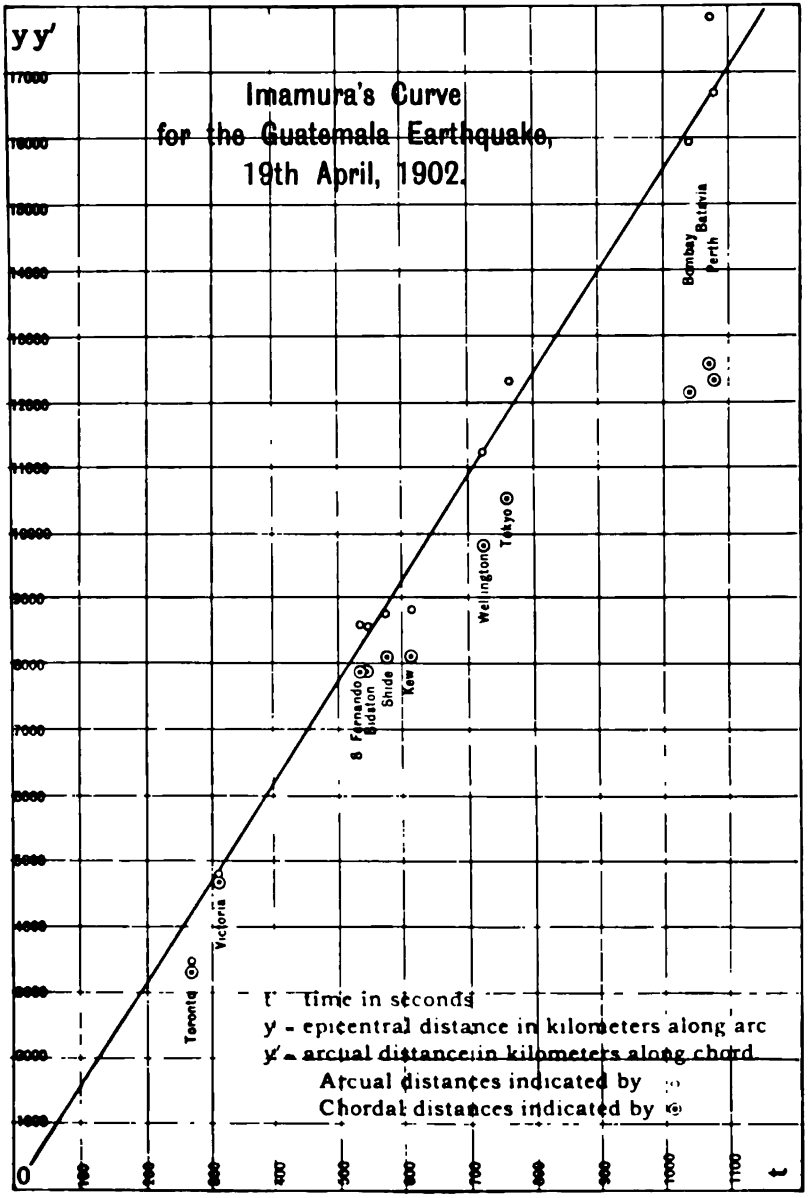
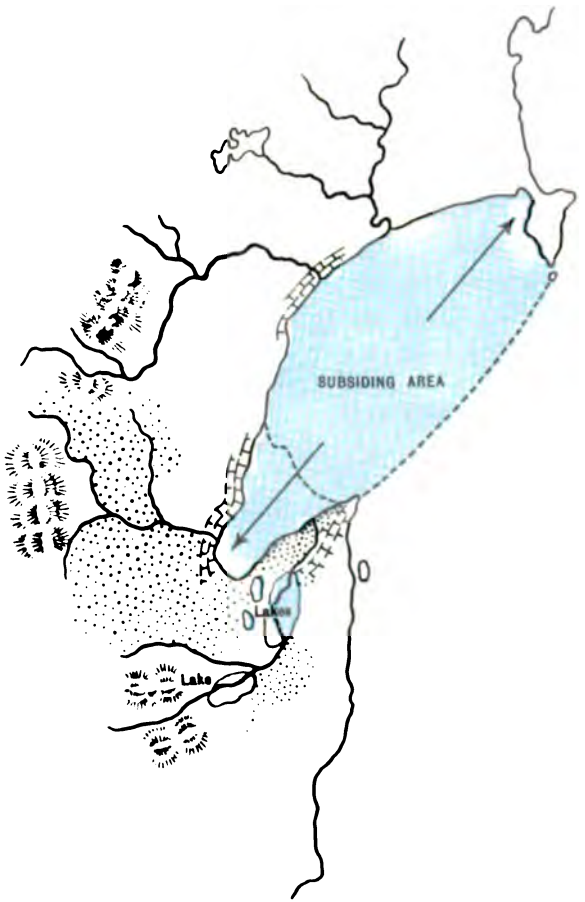


PATH OF EARTHQUAKE WAVES. Hogben.

Map showing Hawke Bay covered with land before subsidence.

Old River System at Period of Great Volcanic Eruptions.

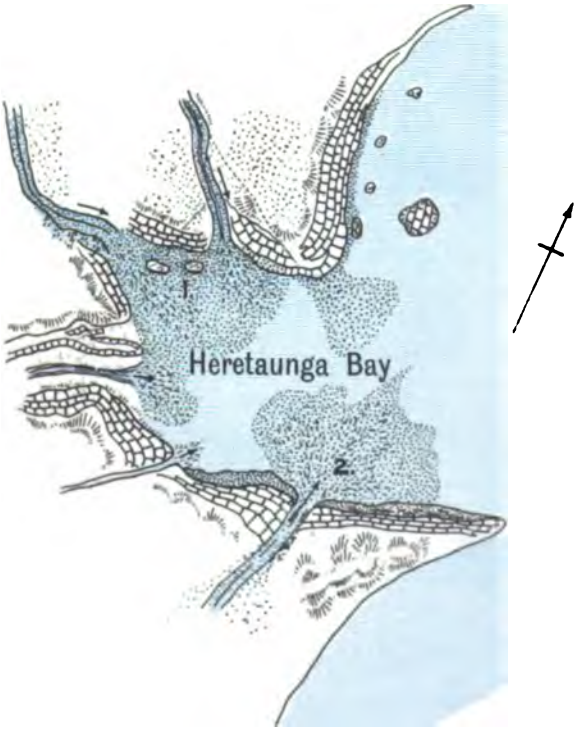
HERETAUNGA PLAIN.—Hill.



Map showing Hawke Bay after subsidence

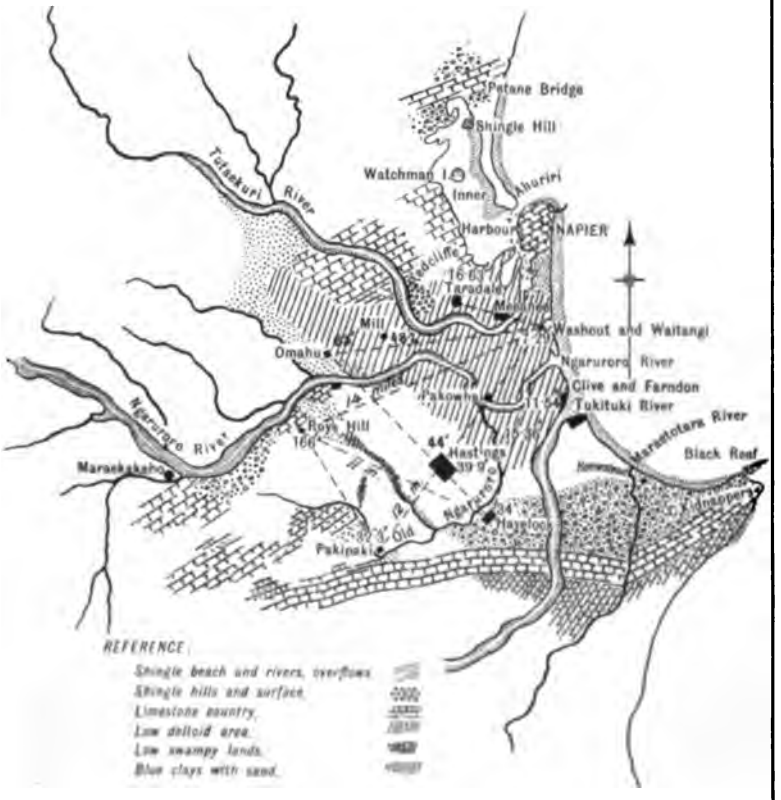
HERETAUNGA PLAIN.—Hill.

Map showing Heretaunga Plain as a bay after subsidence.



1,— Ngaruroro and Tutaekuri.
2,— Tukituki.

Geological and Topographical Map of Heretaunga Plain, showing deltoid area.



HERETAUNGA PLAIN. - Hill.

Fig. 1.—Kidnapper Conglomerates, with pumice and clay beds. Height, 300 ft.

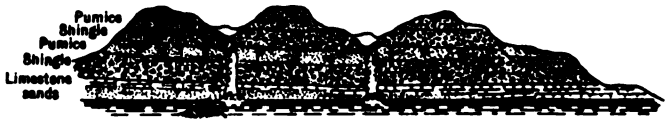


Fig. 2.—Section showing growth of beds forming Heretaunga Plain, extending 10 miles seaward and 10 miles landward.

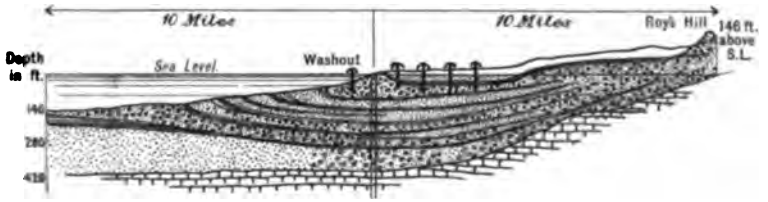
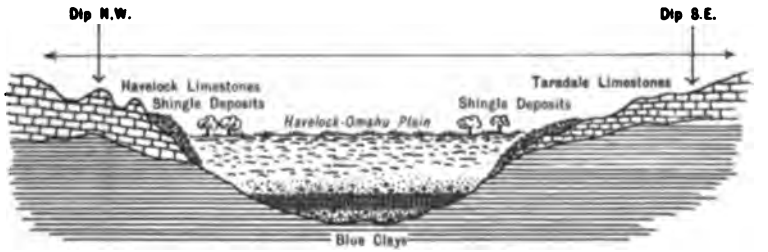
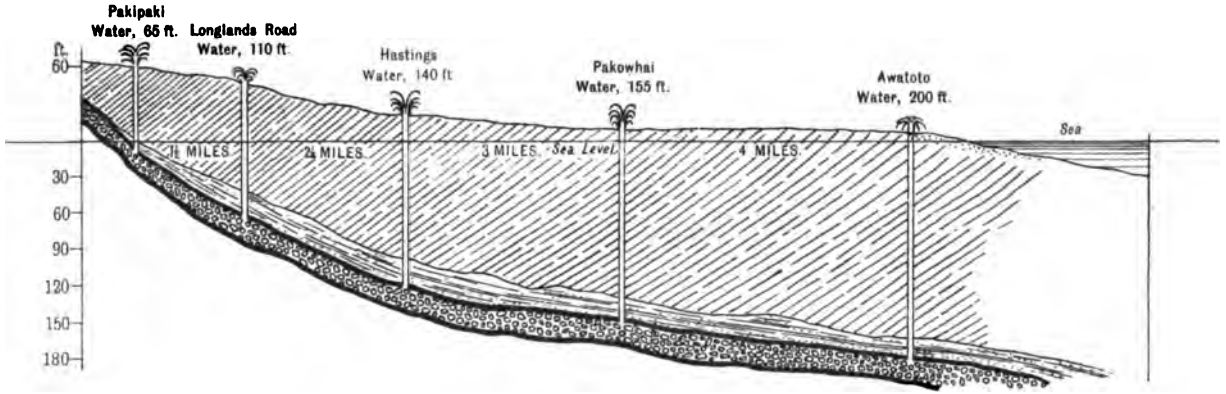


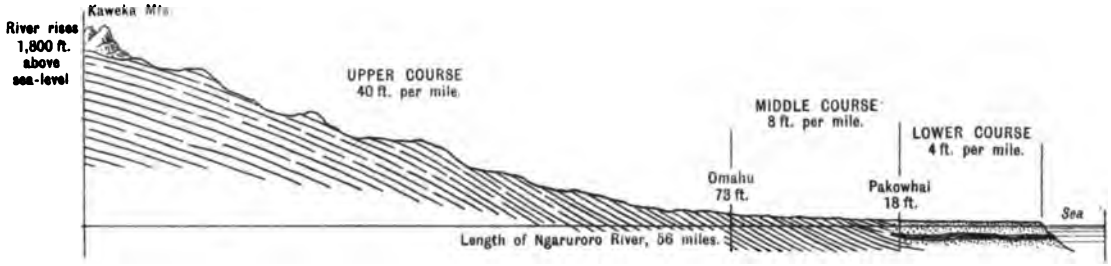
Fig. 3.—Cross Section, Havelock to Omahu, filled by river products.



HERETAUNGA PLAIN.—Hill.

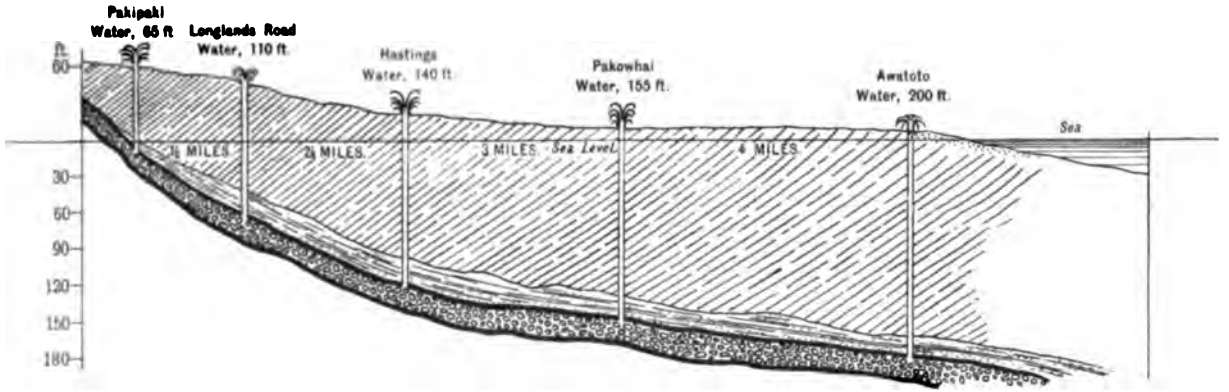


Section showing dip of water-bearing beds from Pakipaki to Awatoto.

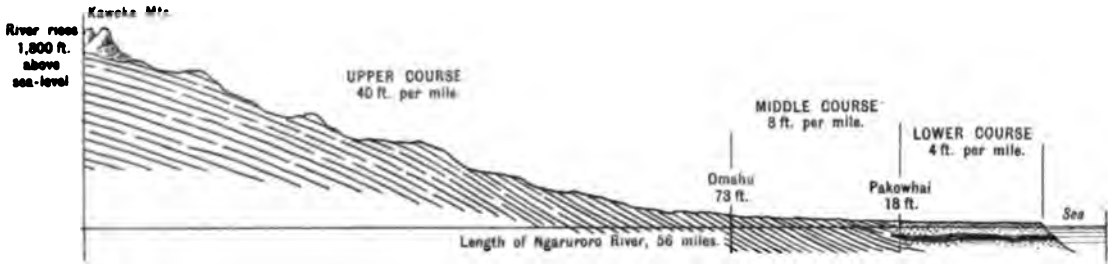


Section illustrating Slope of Ngaruroro River.

HERETAUNGA PLAIN.—Hill.



Section showing dip of water-bearing beds from Pakipaki to Awatoto.



Section illustrating Slope of Ngaruroro River.

HERETAUNGA PLAIN.—Hill.

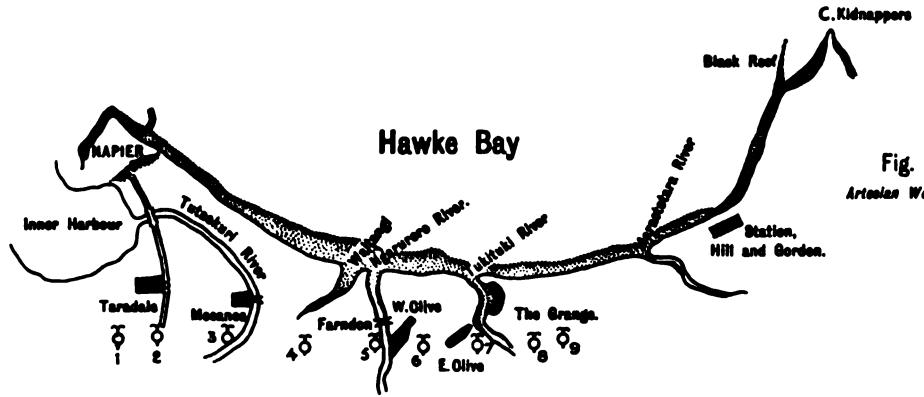


Fig. 2
Artesian Wells, ♂

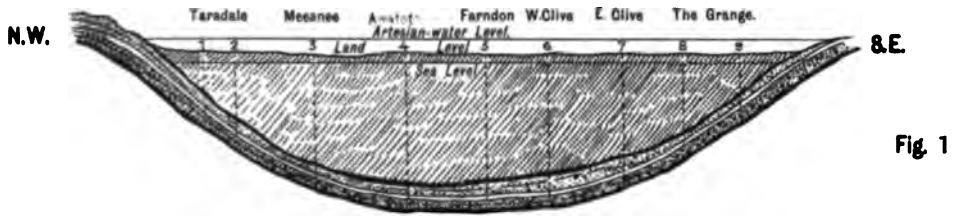
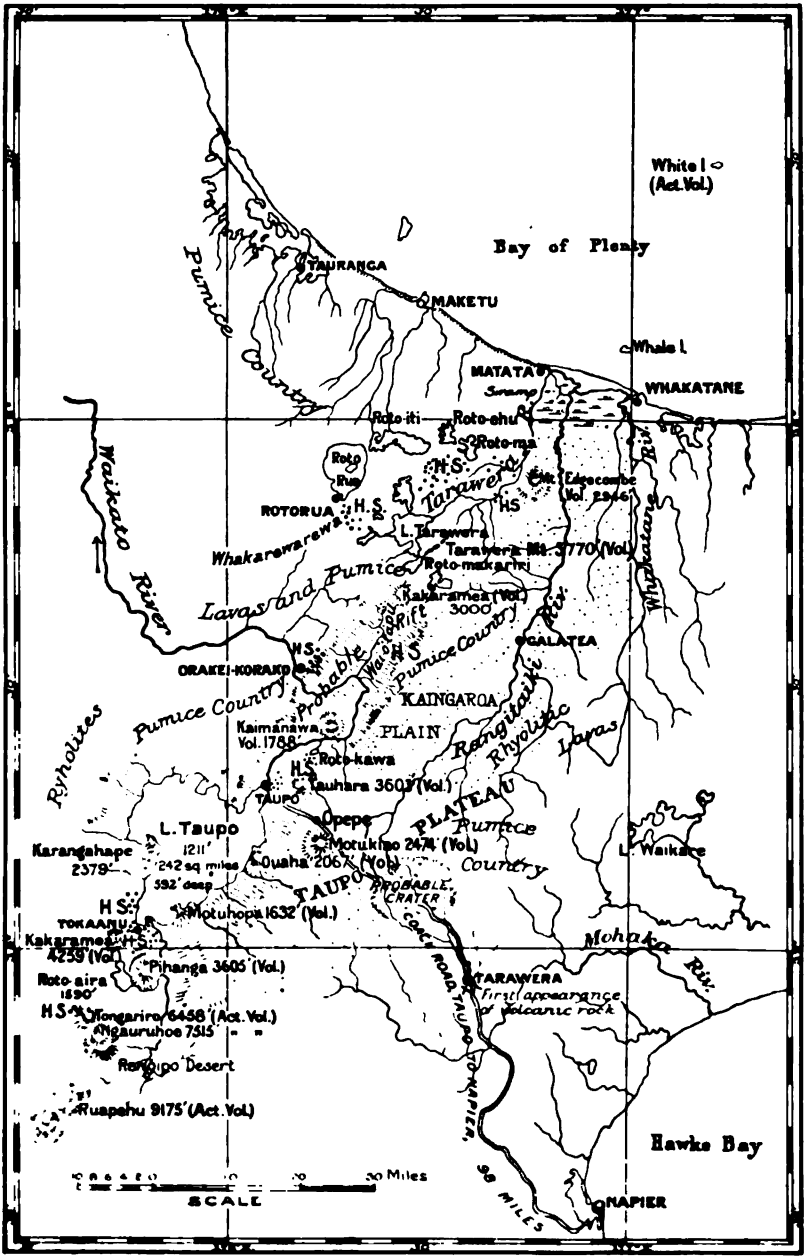
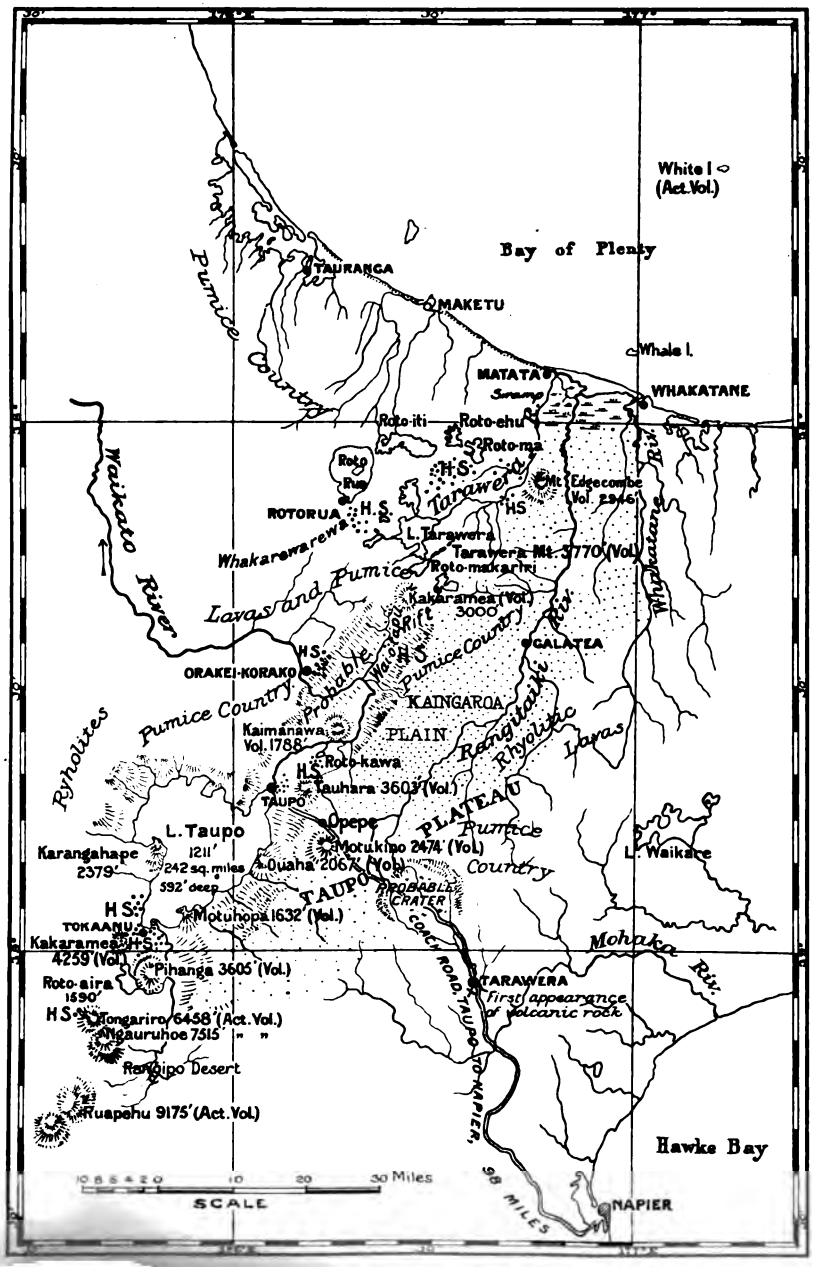


Fig. 1

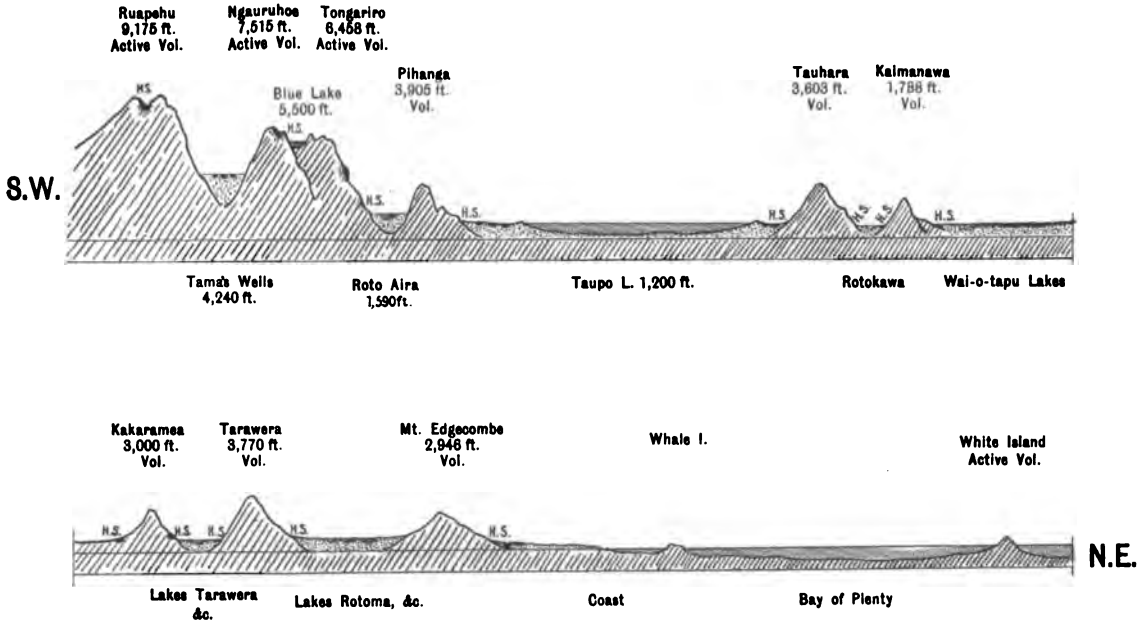
Section N.W. to S.E., across dip of Artesian Beds, showing Valley Basin from Taradale to Mouth of Tukituki River.



TAUPO PLATEAU AND LAKE. Hill.

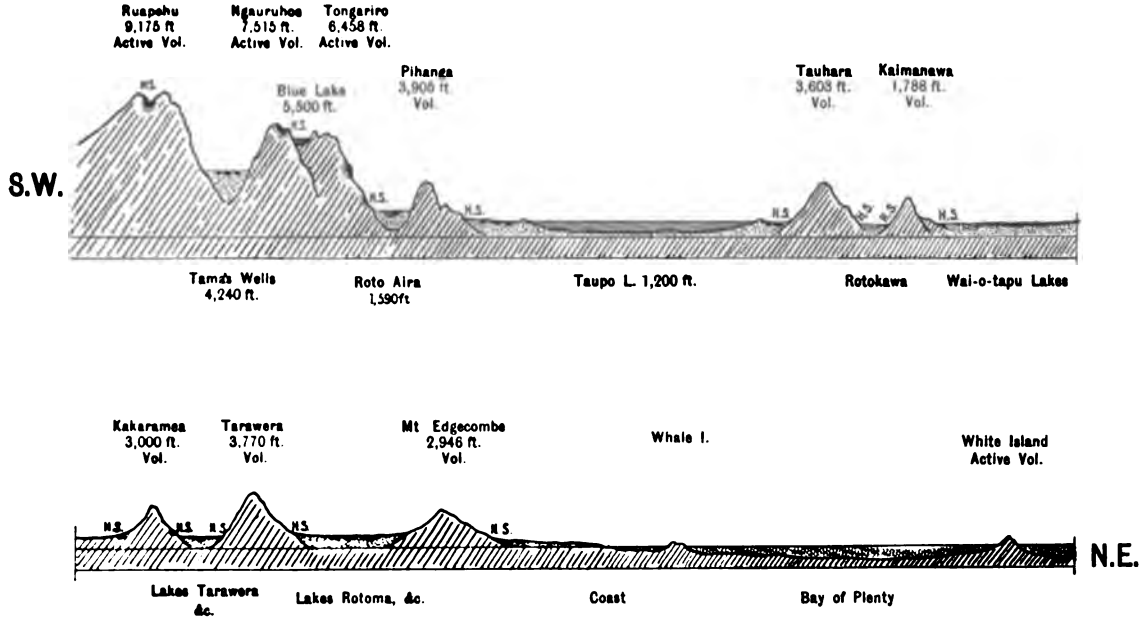


TAUPO PLATEAU AND LAKE.—Hill.



Ruapehu to White Island, showing Volcanic Cones and Lakes.

TAUPO PLATEAU AND LAKE.—Hill.



Ruapehu to White Island, showing Volcanic Cones and Lakes.

TAUPO PLATEAU AND LAKE.—Hill.

2

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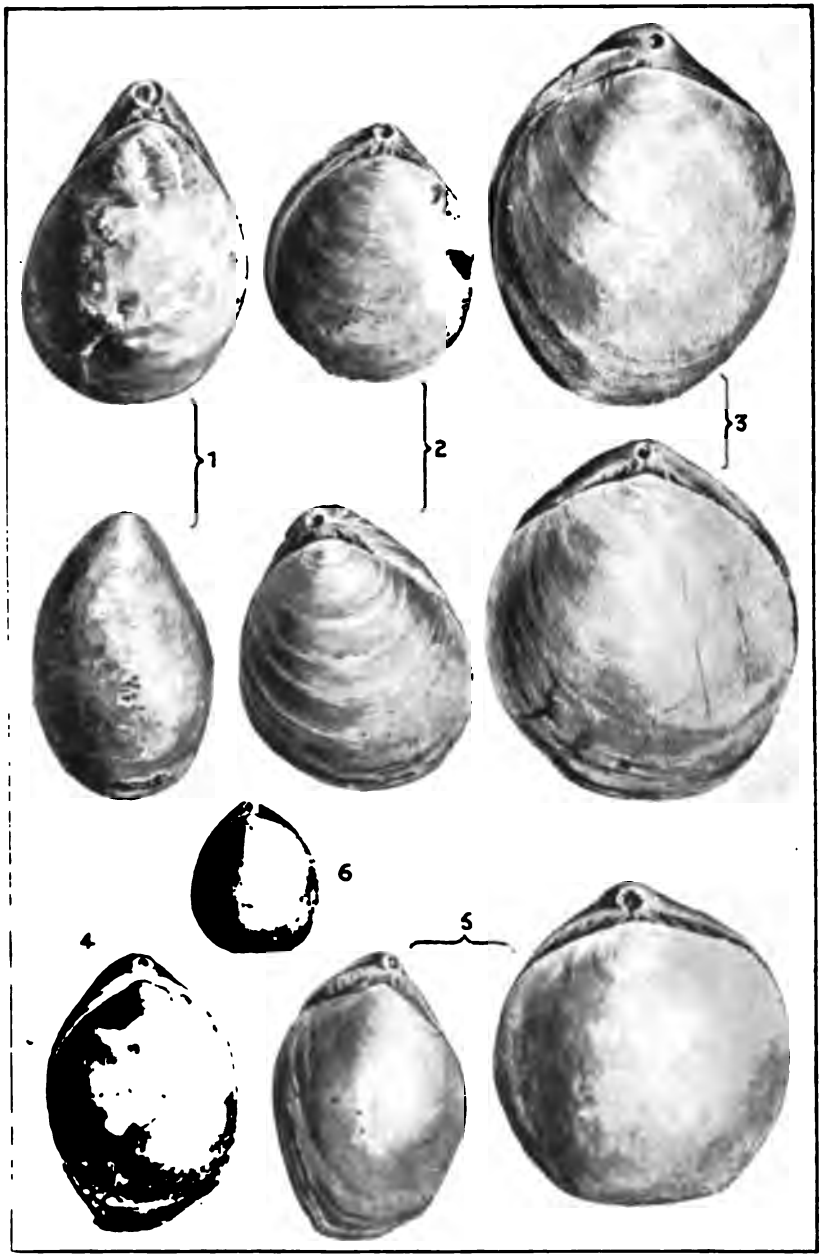
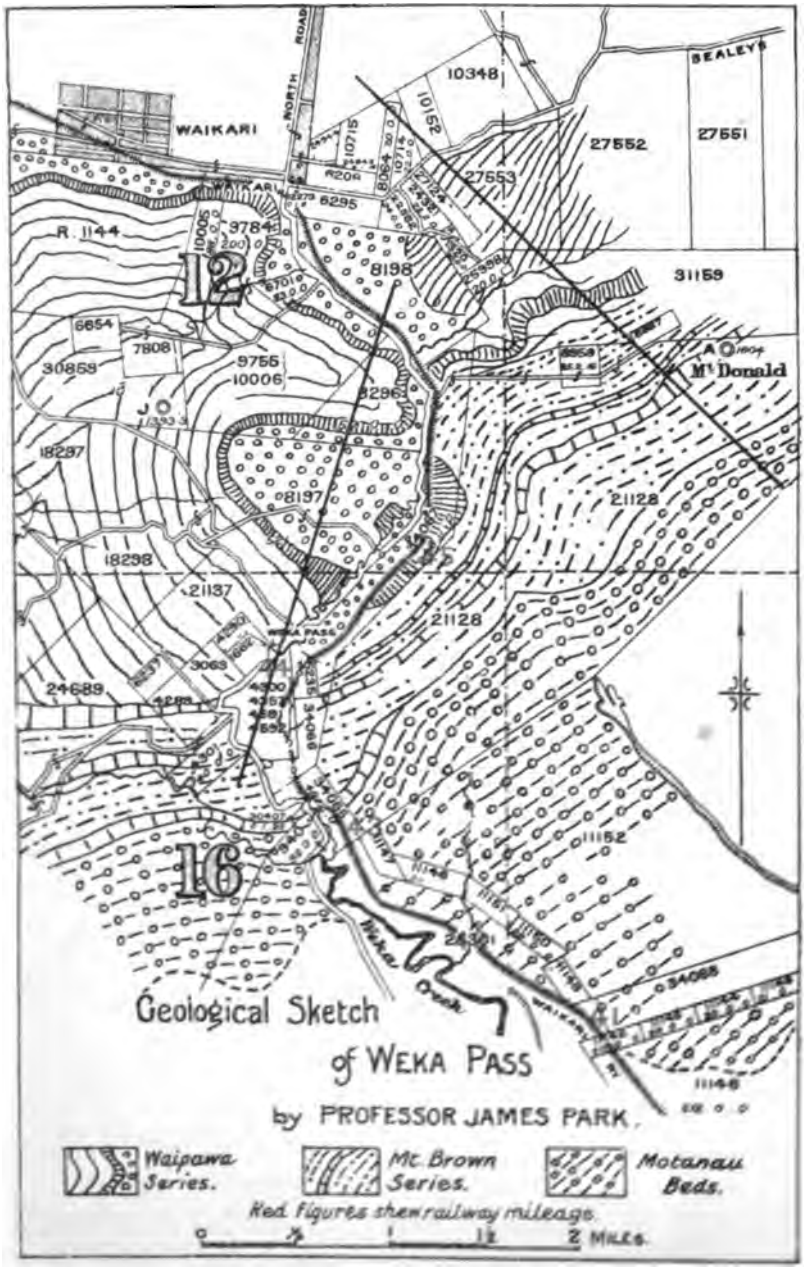
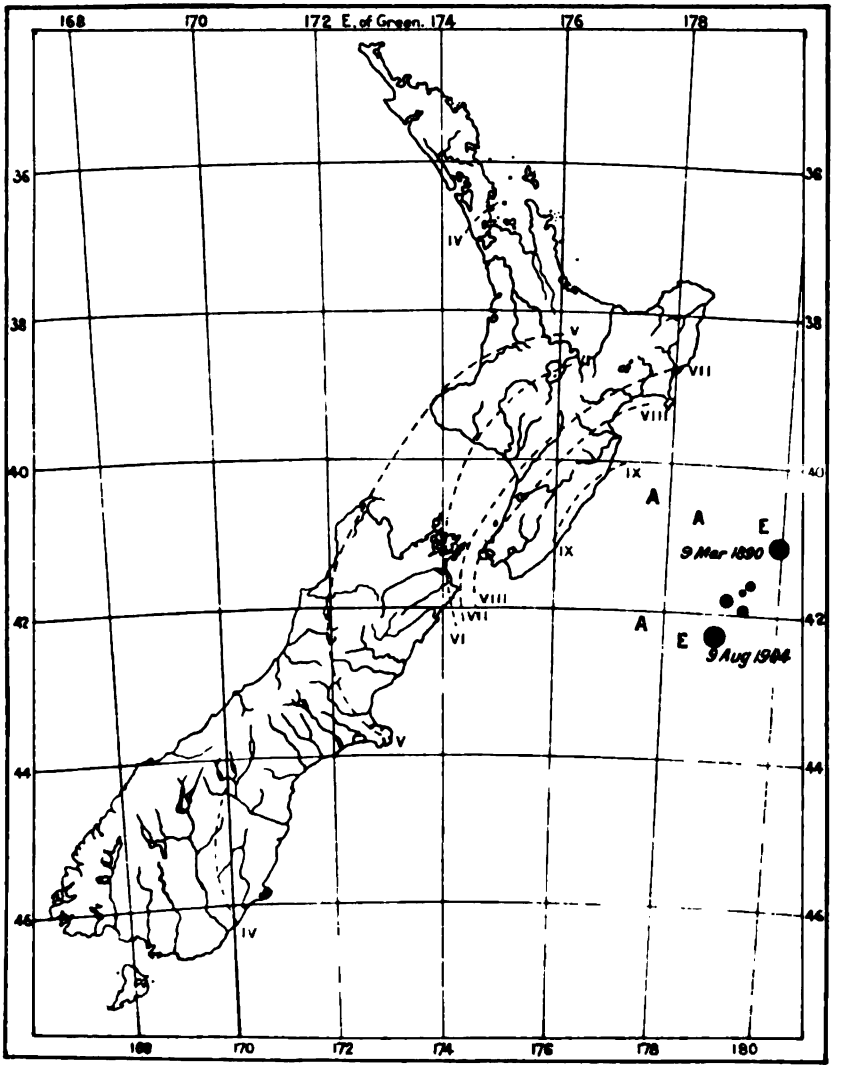
NEW TERTIARY SHELLS. Hutton.



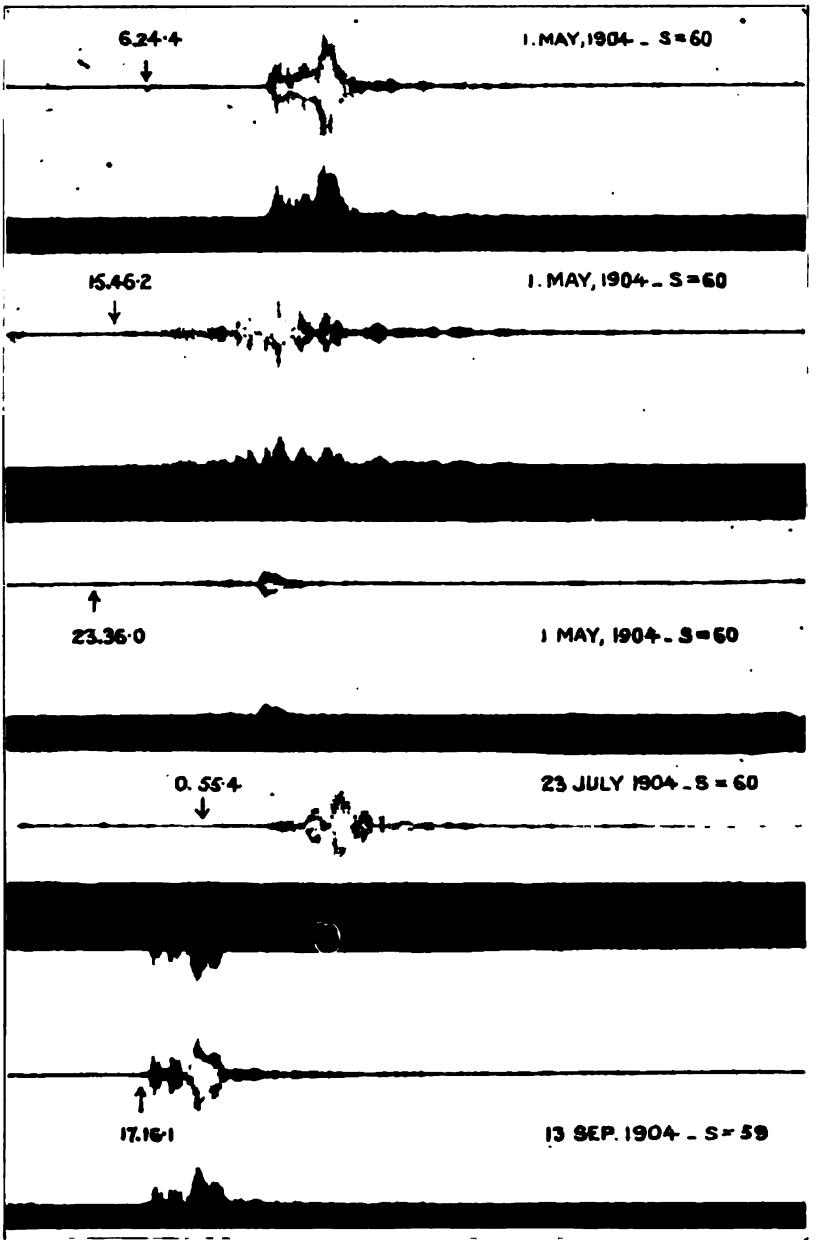
TERTIARY BRACHIOPODA.—Hutton.



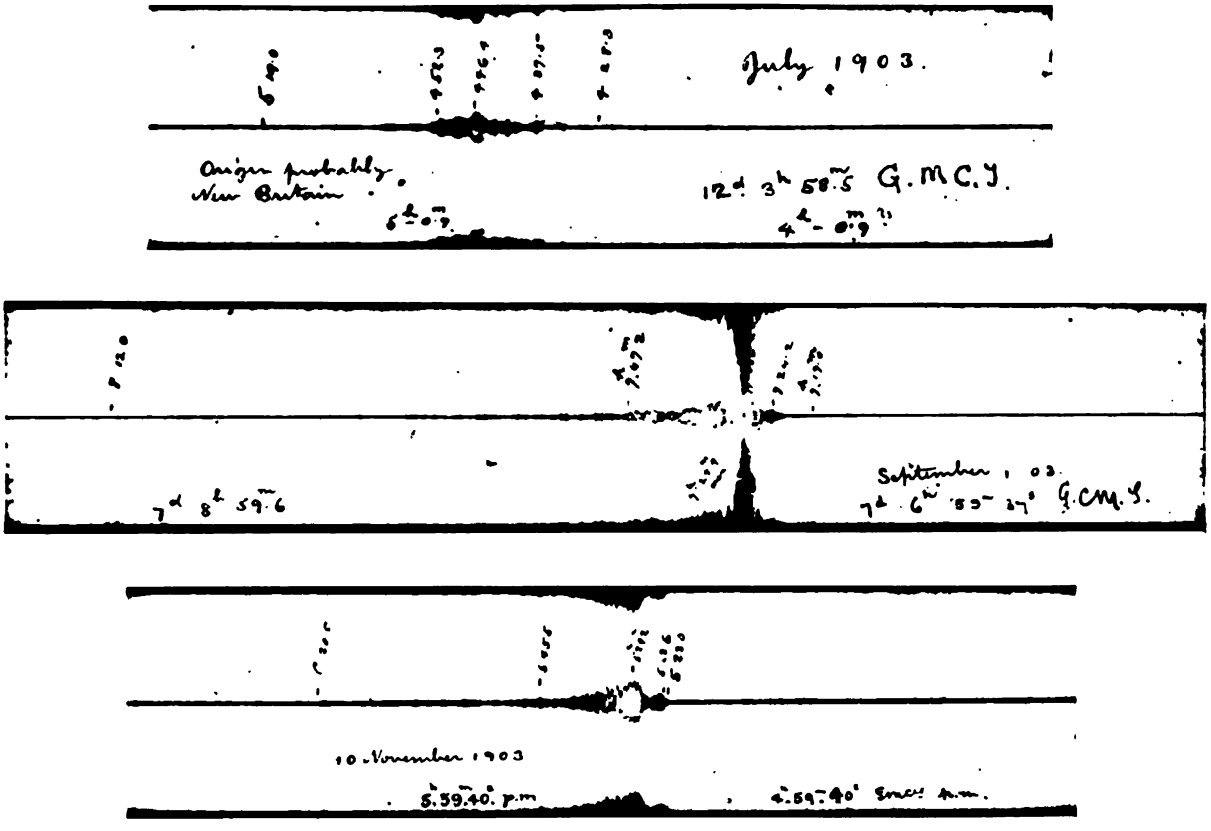
To illustrate paper by Jas. Park.



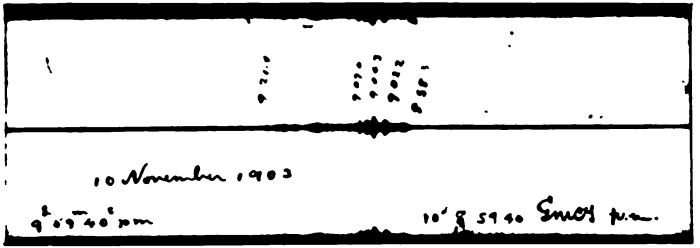
EAST COAST EARTHQUAKE.—Hogben.

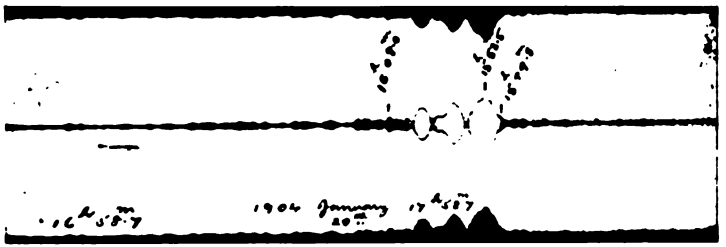


SEISMOGRAMS, WELLINGTON OBSERVATORY.

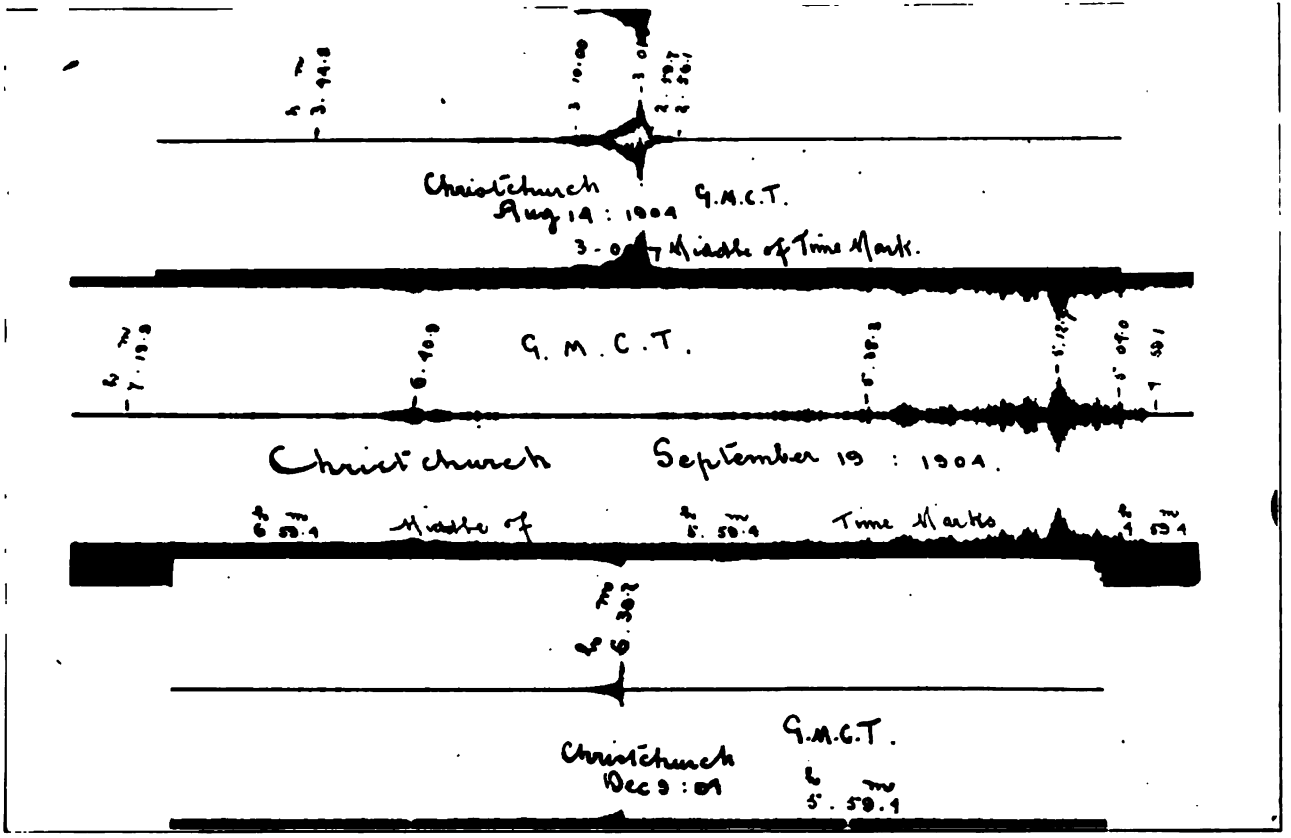


SEISMOGRAMS, CHRISTCHURCH OBSERVATORY.





SEISMOGRAMS, CHRISTCHURCH OBSERVATORY.



SEISMOGRAMS, CHRISTCHURCH OBSERVATORY.